

EXHIBIT 31

‘Hero’ exchanged fire with gunman, then helped chase him down

By [Saeed Ahmed](#), [Doug Criss](#) and [Emanuella Grinberg](#), CNN

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Driver: Hero left his shoes, picked up gun

01:25 - Source: [CNN](#)

(CNN) — The deadliest shooting in Texas history could have claimed even more lives if it weren't for two strangers who jumped into action, authorities said.

When Devin Patrick Kelley opened fire inside First Baptist Church in Sutherland Springs on Sunday, Stephen Willeford, who lives near the church, grabbed his own gun and ran out of the house barefoot to confront the gunman.

“What do you say to the man who stepped up when he heard the gunshots? I'd say he's a hero,” Wilson County Sheriff

Joe Tackitt Jr. told CNN's Chris Cuomo on Monday. "I don't think there's any question about that. Had he not done what he did, we could have lost more people."

As Kelley sped away in a pearl-colored Ford Explorer, Willeford knew he still had a part to play. He spotted Johnnie Langendorff's truck across the street and hailed him down.

"I said, 'that guy just shot up the Baptist church. We need to stop him,'" Willeford told CNN affiliate KHBS.

Langendorff didn't hesitate. "I had to make sure he was caught," Langendorff told CNN. "It was, 'Do everything necessary to make sure that this guy is stopped.'"

With that, the hunt for a killer began.



David J. Phillip/AP

Stephen Willeford, right, meets Johnnie Langendorff at a vigil Monday for the shooting victims.

"Let's go"

Kelley entered the small church in the rural town east of San Antonio, firing with a rifle at the congregation attending the morning service. He killed 26 people and injured at least 20 more.



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Willeford heard the commotion and ran outside with his gun as Kelley was leaving the church.

"He saw me and I saw him. I was standing behind the pickup truck for cover," Willeford told KHBS. "It was surreal to me that it could be happening. I could not believe it."

The two exchanged gunfire. "I know I hit him. I don't know where I hit him," Willeford said. Law enforcement said Willeford struck him in the leg and torso.

Willeford loaded his magazine as fast as he could, his cousin, Ken Leonard, told CNN's Brooke Baldwin. "He didn't even know how many rounds he had put in the magazine."

Kelley got into his vehicle and fired off rounds through the driver's side open window as drove away, Willeford said. That's when Willeford approached Langendorff for a ride.



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Langendorff said he was driving by the church on the way to his girlfriend's house when he saw Kelley and Willeford with their weapons drawn.

"There was exchange of gunfire. It lasted just a few seconds, and the shooter got in his vehicle and took off," he told CNN.

Willeford opened Langendorff's door, told him the gunman had shot up the church and urged the driver to step on it.

"We got to chase him," Willeford said, according to Langendorff. He said he answered, "Let's go."

They led police to the gunman

Kelley was far out of sight as the two took off down 539, but Langendorff hit the gas. Each time he looked down at the speedometer, it was between 90 and 95 mph, he said.

Eventually, they had him in their sights. While weaving between cars on the country road they called 911 to offer directions.

The chase had lasted about 10 minutes when Kelley veered off to the side of the road as if to pull over, Willeford told KHBS. Then, Kelley hit a stop sign, lost control and came to a stop in a ditch near the county line, he said.

Willeford said he got out of the car, propped his rifle on the hood, and yelled at Kelley to get out of the car. Langendorff said he ran into the road to direct traffic.

"I never saw any movement, but I wasn't gonna let him go anywhere," Willeford told KHBS.

Police arrived about five minutes later and approached the gunman's vehicle. They found Kelley dead inside, with a self-inflicted gunshot wound to the head.



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Asked by CNN what he was thinking at the time, Langendorff said, "Nothing. Get him." Why? "Because that's what you do, you chase a bad guy." And he has no regrets about throwing himself into such a dangerous situation.

The shooting was a horrific tragedy, Langendorff said. "I hope that everyone affected is able to rest a little better knowing that this guy, he'll never breathe again, he said. "It doesn't serve it justice completely. But he won't hurt anyone

...saying that this guy, he'll never breathe again, he said. It doesn't serve it justice completely, but he won't hurt anyone else ever."

Bravery seen at another church shooting

It was the deadliest mass shooting in Texas history – and the fifth deadliest in modern US history.

Willeford's actions were similar to another man's act of bravery during a another church shooting earlier this year in Antioch, Tennessee.

As the service at the Burnette Chapel Church of Christ was ending on September 24, a gunman – whom police identified as 25-year-old Emanuel Kidega Samson – entered the church with a pair of pistols and started firing. An usher at the church, Robert Engle, sprang into action – struggling with the suspect, even as he was being pistol-whipped, police said.



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"Mr. Samson didn't expect Mr. Engle to encounter him, to struggle with him, to try to stop the shooting," said Don Aaron, the spokesman for the Metropolitan Nashville Police Department.

During the altercation, the gunman accidentally shot himself in the chest with his own weapon, police said.

When the gunman fell, Engle, despite his head injuries, ran to his car and came back with a pistol of his own, police said.

Engle, who has a permit for a handgun, then made sure Samson stayed on the ground until officers arrived, Aaron said.

Clarification: This story has been revised to remove a statement by Ken Leonard that Devin Patrick Kelley carjacked a vehicle when the gunman left the scene of the shooting.

CNN's Joe Sterling contributed to this report.

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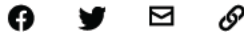
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Despite Shots From Security Guard, 24-Year-Old Murray Killed Himself

The man who killed four people at a church died of self-inflicted gunshot wound.

By ABC News **GMA**

February 26, 2009, 7:53 PM



Dec. 11, 2007 -- The 24-year-old who killed four people at the New Life Church in Colo. was killed by his own bullet.

Police say though he was shot several times by a security officer, who has since been heralded for saving the lives of other potential shooting victims, it was a self-inflicted gunshot wound that killed Matthew Murray.

A picture of the gunman who killed four people at a megachurch and a youth center in Colorado is emerging.

It turns out that Murray was no stranger to Youth With a Mission training center, where his killing spree began.

Five years ago, Murray signed up for the program, but when it came time for field training, he was told he wasn't stable enough to travel with the other students, according to the Rev. Peter Warren, the director of the program.

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"The program directors felt that the issues related to his health made it unsafe for him to do so," said Warren. "Our hearts go out to the Murray family, to who we extend the spirit of love and compassion."

Murray was shot and killed by Jeanne Assam, a volunteer security guard and New Life Church member, but not before he killed four people and injured five others.

Vietnam veteran Larry Bourbannais, 59, was shot in the left forearm by Murray at The New Life Church and was one of the last people to see him alive.

"When he looked at me, it was just a blank stare like he's gonna kill me," Bourbannais said. "Just when the chill went through me is when I heard those guns shots that when I knew it was the real deal."

Murray, the son of a prominent neurologist, grew up in Englewood, Colo., and was home-schooled in what's been described as a deeply religious family. A computer enthusiast, Murray had only one previous brush with the law — a traffic ticket earlier this year.



The Rev. Phil Abeyta, Murray's uncle, spoke on behalf of the family, who he said are grief-stricken over the shootings.

"On behalf of our family and our son we ask for forgiveness," Abeyta said in a statement. "We cannot understand why this has happened. We ask for prayer for the victims and their families during this time of grief."

Murray sent hate mail to the Youth With a Mission in the past, and Denver TV station KUSA reported that he posted several rants on a Web site for people who have left evangelical religious groups. The most recent post was Sunday morning, the station said, but it was removed after the killings.

Sunday morning, Murray acted out his anger, arriving at Youth With a Mission in Arvada about 12:30 a.m., and killing Tiffany Johnson, 25, and Phil Crouse, 22.

Thirteen hours later, he opened fire at The New Life Church in Colorado Springs, killing sisters Stephanie Works, 18, and Rachael Works, 16.

"It's hard knowing that I never really got to say goodbye," said Michaela Simonds, a friend of the sisters. "But they are in a better place and I will see them again someday."

Their father, David Works, 51, was wounded and listed in fair condition at an area hospital. Parishioner Judy Purcell, 40, was also injured.

Police say in the second attack, Murray was carrying an assault rifle, two handguns, smoke bombs and 1,000 rounds of ammunition. Police did not say where Murray obtained the items.



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EXHIBIT 33

Review Paper Trauma

Wound ballistics of firearm-related injuries—Part 1: Missile characteristics and mechanisms of soft tissue wounding

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P. K. Stefanopoulos, K. Filippakis, O. T. Soupiou, V. C. Pazarakiotis: Wound ballistics of firearm related injuries Part 1: Missile characteristics and mechanisms of soft tissue wounding. Int. J. Oral Maxillofac. Surg. 2014; 43: 1445–1458. © 2014 International Association of Oral and Maxillofacial Surgeons. Published by Elsevier Ltd. All rights reserved.

Abstract. Firearm related injuries are caused by a wide variety of weapons and projectiles. The kinetic energy of the penetrating projectile defines its ability to disrupt and displace tissue, whereas the actual tissue damage is determined by the mode of energy release during the projectile–tissue interaction and the particular characteristics of the tissues and organs involved. Certain projectile factors, namely shape, construction, and stability, greatly influence the rate of energy transfer to the tissues along the wound track. Two zones of tissue damage can be identified, the permanent cavity created by the passage of the bullet and a potential area of contused tissue surrounding it, produced mainly by temporary cavitation which is a manifestation of effective high energy transfer to tissue. Due to the complex nature of these injuries, wound assessment and the type and extent of treatment required should be based on an understanding of the various mechanisms contributing to tissue damage.

Keywords: Wound ballistics; Gunshot wounds; Missile injuries; Ballistic injuries; High energy missile trauma.

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“Dans les champs, le hasard ne favorise que les esprits préparés” (In the field [of observation], chance favours only the prepared mind)

Louis Pasteur

The wounding power of firearms is an important issue in penetrating trauma,

both war and civilian,^{1–6} and as such it may also affect surgeons with little knowledge or concern about weapons and their effects. The study of these effects produced by missiles has been termed ‘wound ballistics’,⁷ indicating its subordination to the science of projectile motion. In this context, the term missile implies small projectiles capable of tissue penetration because of their energy rather than their

shape.⁸ Wound ballistics examines the relationship between the properties of the missile and the severity of the resultant wound, and the role of the various mechanisms of ballistic penetration in the production of tissue damage.⁹ These aspects apply to battle casualties, the majority of which are caused by munition fragments rather than bullets,^{1,10–13} as well as to ballistic injuries seen during peacetime.

In both of these environments, the maxillofacial region represents a prominent location for missile injuries,¹⁴⁻¹⁷ but it is mainly due to civilian firearm violence that this area often appears as an intentional close range target, whether the consequence of assault or suicide attempt.¹⁸⁻²¹ In the face, the close anatomical relationship of soft and hard tissues results in a complex pattern of firearm related injuries,²² with comminution of bone and teeth as a common feature.^{23,24} Furthermore, the amount of non viable tissue following ballistic trauma remains a critical concern, especially when primary reconstructive procedures are contemplated.^{18,25,26} Although the assessment of the unique consequences of these injuries is a subject of surgical judgement, an understanding of wound ballistics can provide the basis for interpretation of the mechanism of tissue damage with respect to its extent along the wound track; in this way the surgeon is also prepared for potential complications.²⁵⁻²⁸ In this paper, the first of two, we present the wounding effects of small arms projectiles on soft tissue. In the second part, the pathophysiology and ballistic aspects of maxillofacial missile injuries are discussed.

Wounding agents

Firearm related injuries among the civilian population are commonly inflicted by handguns, rifles, and shotguns.^{18,29,30} These weapons are included under the military term 'small arms',³¹ and are

generally defined by their type and calibre (diameter).

Handguns and rifles

Both handguns and rifles are rifled firearms. Rifling is an important feature of all firearms except shotguns, indicating a series of spiral parallel grooves cut into the bore (the inner surface of the barrel).^{18,29-35} Calibre refers both to the diameter of the bore and the bullet maximum diameter.³⁶⁻³⁸ It is expressed either as a decimal fraction of an inch (with the nought in front of the decimal point usually omitted) to designate American and British weapons and cartridges,^{29,31,37-39} or in millimetres based on the metric designation system,^{29,38-40} which is the standardized method for sizing military ammunition.^{31,35,38}

Handguns are of two major types, revolvers and auto loading pistols. They are the most frequently used type of firearm in civilian conflicts.^{6,18,31,41,42} Common handgun calibres range from .22 to .45 in. (Fig. 1). The more rarely encountered submachine guns are truly automatic weapons typically using handgun ammunition.^{31,35}

Rifles are the most powerful of the commonly encountered small arms,^{31,41,42} and they are categorized into two main classifications, those for military use, called assault rifles, and the hunting rifles.^{42,43} Assault rifles use ammunition of smaller calibre than most handguns and are capable of firing either single shots (semi automatic fire) or in bursts (fully

automatic fire) through the use of a selector level. Most renowned are the Russian AK 47 (Kalashnikov; calibre 7.62 mm) and the American M16 (calibre 5.56 mm). Civilian versions of assault rifles, such as the AR 15 edition of the M16, normally lack the fully automatic mode.⁴²

Ammunition

The cartridge (round of ammunition) is the functional unit of firearm ammunition, renewed for each firing. The bullet is the part of the cartridge that hits the target and does not refer to a complete round of ammunition. The round consists of the cartridge case containing the propellant ('powder'), with the bullet mounted on the open end of the case and the primer incorporated into the opposite closed end (base or head).^{18,30,31,37,44}

Combustion of the powder ignited by the primer produces rapidly expanding gases which propel the projectile out of the cartridge case and down the barrel of the gun.³⁷ During its acceleration, the bullet attains two types of motion simultaneously, forward translation and also rotation on its longitudinal axis (spin) as it encounters the grooves of the rifled bore (Fig. 2).⁴⁴ Spinning serves to gyroscopically stabilize the bullet during its flight, thus increasing both its range and accuracy.^{3,31,33,34,36,43-46}

Most bullets are composed primarily of a lead alloy, but lead free (non toxic) metallic bullets are also available.^{31,38} Bullets are either solid or jacketed. Jacketed bullets have a core of lead or mild steel covered by a coating (jacket) of a harder metal, such as cupronickel or a steel alloy,^{30,31,36,38,39} and they come in two basic constructions.⁴⁷ Partially jacketed (semi jacketed) bullets have the tip either simply left exposed ('soft point') or hollowed out ('hollow point'); they typically flatten or 'mushroom' when striking soft tissue with sufficient velocity,^{31,48} hence they are known as expanding bullets. Full metal jacketed (FMJ) bullets, also known as 'ball ammunition', have the jacket enclosing the tip to prevent it from such deformation.^{22,31,38,41-43,47,49} Rifle bullets are jacketed in order to prevent the soft lead core being stripped and deposited in the rifling at the high velocities accomplished.^{31,47}

An unfortunate term for expanding bullets is 'dum dum'.⁴⁸ It essentially refers to a modification of the official military FMJ .303 British rifle bullet, made for the British Indian Army in 1897 at the Dum dum arsenal near Calcutta. That



Fig. 1. Examples of pistol ammunition. From left to right: .38 Super; 9 mm Luger; .40 Smith & Wesson (S&W); .45 Automatic Colt Pistol (ACP). The former two are essentially of the same diameter, but the .38 Super is more powerful as indicated by its considerably longer cartridge case containing larger propellant charge. Note also the truncated 'semiwadcutter' (SWC) configuration of the .40 S&W compared to the more common round nose shape of the other bullets. (One cent coins are shown for comparison.)

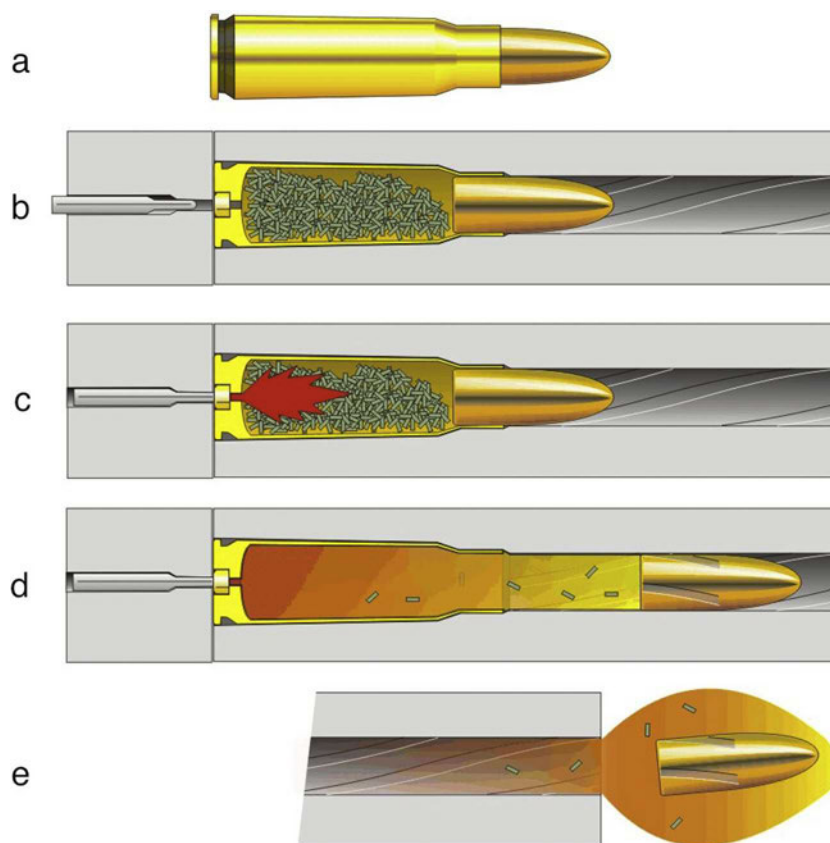


Fig. 2. Artistic drawing of a rifle cartridge, (a) intact and (b) in the gun chamber just before firing with the cartridge case cut across to demonstrate the primer and propellant powder. (c) The irreversible firing process activates the firing pin which serves to strike the primer, the latter producing a minute explosion. (d) This ignites the powder generating the propellant gases, which accelerate the bullet down the barrel, while at the same time it attains rotation (spin) as it encounters the rifled bore. (e) During the exit from the muzzle, slight deviation of the body of the bullet from its axis of flight occurs.

Reproduced from Ref. 37, courtesy of Professor Jorma Jussila.

bullet had its jacket opened at the tip with 1 mm of the lead core exposed⁵⁰ in order to deform and thereby produce greater wounding effect.^{40,51-55} For humanitarian reasons, any similar expansible construction has been banned by the Hague Convention of 1899,⁵¹⁻⁶⁰ and FMJ ammunition has become the standard form allowed for military purposes (Fig. 3).^{35,36,51,54,58}

Where soft point and hollow point bullets are legitimately in use by civilians, the former type is most popular for hunting rifles and the latter for handguns (Fig. 4).³¹ Newer designs of hollow point handgun bullets that mushroom more consistently have been introduced, such as the Hydra Shok and the 9 mm Luger bullets Blitz Action Trauma (BAT) and Action 4.^{22,31,38} Handgun ammunition containing small pellets is also commercially available, releasing them either within the barrel or upon impact with the target, as with the Glaser Safety Slug.^{31,36,42,48,61}

The generic suffix 'Magnum' implies an increased amount of propellant loaded in a longer case than standard cartridges.³¹ The term is not specific to a larger calibre as commonly believed. The .357 Magnum (Fig. 5) introduced in 1935 was based on the .38 Special cartridge, actually of the same bullet diameter, but it provides nearly double the velocity and more than three times greater muzzle energy than the standard .38 Special loads.⁴⁰ Magnum also refers to heavy frame firearms specifically chambered for Magnum cartridges.²⁹

Shotguns

Shotguns have a smooth bore, the diameter of which is designated by gauge rather than calibre, with the exception of the .410 calibre.^{31,62-64} In general, the higher the gauge number, the smaller the barrel diameter.^{31,64} Shotguns fire either multiple pellets or a single large projectile called a

slug.^{30,31,62-64} Pellets are contained within the shotgun cartridge called a shell, and are collectively known as the shot (Fig. 6)⁶³; their number depends on their size and the gauge of the gun.⁶² Magnum shotgun shells contain more propellant and a heavier charge of shot (more pellets).³¹ In general, pellets range in diameter from 1 to 10 mm, falling into two major categories, the more common birdshot, which refers to smaller shot size, and buckshot.^{31,42} Wadding, commonly in the form of a plastic insert, is used to isolate the shot from the propellant and prevent it from rubbing against the inner wall of the barrel.^{31,38,64}

Shot charge and wadding are the components that leave the muzzle upon firing,^{61,62} following which the shot expands and lengthens.³⁸ The distribution of pellets, referred to as pattern,⁶³ is effectively determined by the choke, a constriction of the bore at the muzzle end of the barrel.^{31,40,62}

Wound ballistics

The physics of the motion of projectiles are classically described under a number of sections. Internal (interior) ballistics deals with the acceleration phase within the gun barrel, being applicable to missiles fired from barrelled weapons.¹⁰ External (exterior) ballistics studies the flight of the projectile through air, whereas terminal ballistics studies the behaviour of projectiles during penetration of solid materials.^{7,9,10,24,31,45,65-67}

Wound ballistics is a term originally used by Callender and French⁶⁸ to introduce a special branch of terminal ballistics, which addresses the effects of projectiles on living tissues, either animal or human, or on tissue simulants.^{7,66,69,70} These effects are determined by a number of factors, both projectile and tissue related. Upon impact, various properties of the missile combine to create disruptive forces producing tissue damage (Table 1); the retentive forces by which tissue strives to retain its integrity react against these factors.^{3,7,67} This projectile tissue interaction represents the central event in ballistic tissue penetration,^{1,71} as it is only during this process that certain features of the projectile, mainly related to its construction and design, which largely determine its terminal behaviour, become apparent.^{34,45}

Wounding power and wounding effects

The tissue damage that a bullet is capable of represents its wounding power, also



Fig. 3. Examples of military rifle ammunition, identified by calibre and cartridge case length, both in millimetres. From left to right: 5.56×45 mm NATO, used in the M16 rifle; 7.62×39 mm Russian (Kalashnikov) used in the AK 47 rifle; 7.62×51 mm NATO; 7.62×54 mm (Rimmed) (Mosin Nagant); .30 06 Springfield (7.62×63 mm) used in the M1 Garand rifle, also a very popular hunting cartridge in the USA.

referred to as the wounding potential.⁷² It is related to two basic ballistic parameters, mass and velocity.^{72–76} As a function of these parameters, the kinetic energy possessed by the projectile at impact is thought to provide the best estimate of wounding power.^{18,34,43} This widely accepted theory has led to the common misconception that the tissue damage produced can be adequately predicted in terms of the familiar kinetic energy (KE) formula ($KE = \frac{1}{2}mv^2$), with emphasis placed on the velocity component (v) as it enters the equation raised to the second

power. This, however, represents an oversimplification,^{5,8} since it does not take into consideration the projectile tissue interaction.^{12,66,75,77}

Muzzle velocity is the maximum velocity of the bullet as it leaves the muzzle,^{10,29,74} while the impact (striking) velocity is the one recorded when the bullet hits the target. Whereas velocity decreases with distance according to the laws of external ballistics,^{74,78} in most civilian wounds inflicted at close range, the impact velocity can be considered approximately equal to the muzzle



Fig. 4. 9 mm Luger hollow point cartridge (middle), compared to two full metal jacketed cartridges, of the same calibre (left) and .45 calibre (right). Note the manufacturer's scoring of the jacket around the hollowed tip to facilitate expansion.

velocity, which can be found published in ballistic charts.²⁹

Projectiles are loosely classified into 'low velocity' and 'high velocity' categories,^{8,35} which roughly correspond to muzzle velocity characteristics of handguns and rifles, respectively.^{5,28,73} Military rifles typically have muzzle velocities that exceed 700 m/s, whereas those delivered by conventional handguns are in the range between 250 and 370 m/s. Accordingly, as pointed out by Kneubuehl,⁶¹ the commonly used distinction between 'low velocity' and 'high velocity' bullet wounds serves, if at all, only as a form of general differentiation between wounds caused by handguns and rifles. Rifle bullets cause certain effects, mostly related to a significantly larger amount of energy imparted to tissues, that are almost undetectable with conventional handgun bullets.^{28,61,79} The clinical implication is that 'high velocity', generally defined as exceeding 600 m/s,⁴⁵ is considered synonymous to the most severe missile injuries, relating the specific character of the wound to the speed of the penetrator.^{8,80,81} However, current thinking suggests that the impact velocity can be misleading as the sole indicator of the extent and severity of the inflicted wound,^{1,18,35,57,76,77,82} although it influences other factors that may have overall greater effect upon the wounding process.^{56,83} Furthermore, mass is also important, as a heavier missile better maintains its speed in flight due to its higher inertia, and is potentially more damaging for a greater penetration depth in tissue compared with a lighter one with the same or even higher impact velocity.^{9,34,45}

The kinetic energy of a penetrating projectile constitutes the only available amount of energy for work to be performed within tissue⁷⁰; however, it is only the energy delivered to tissue itself that can result in wound production.^{5,8,34,38,81,82,84–86} Consequently, thinking in terms of kinetic energy absorption provides a working knowledge of the extent of the resultant tissue damage,^{34,87} as the former has been proved a physically consistent means of explaining damage that occurs both locally and at some distance from the projectile path,⁸⁸ as well as a measure of wound comparison.⁸⁹ Based on these premises, the current classification of ballistic injuries into those produced by either 'low energy' or 'high energy' transfer is more appropriate than previous classifications defined by the type of weapon or its power.^{1,11,45,57,70,82,87}

The descriptive term 'high energy missile trauma',⁵⁵ in particular, refers to the



Fig. 5. .357 Magnum jacketed soft point (JSP) revolver cartridge. Note the characteristic longer case containing high power loading.

ballistic wound pattern produced by a substantial quantity of kinetic energy. Although some authors regard 400 J as the cut off between low and high energy deposition into tissues,³² it is important to understand that the designation 'high energy' is used in this context to define the wounding effect rather than the amount of energy used up.^{55,82,90,91} Nevertheless, in quantitative terms, a 'high energy' wound results from a typical assault rifle bullet at velocities between 600 and 1000 m/s, depending on range. In such a case, the net amount of energy deposited into tissues will vary from one hundred to a few hundred Joules and in exceptional cases up to thousands.⁸²

However, the human body is not a homogeneous target, and the local effects induced by a missile also depend to a large extent on the viscoelastic properties of the various tissues,^{4,7,45,73,83} which may react in different ways to missiles of the same size and velocity.^{12,57} Although the

damage produced appears to be proportional to the amount of energy delivered to the tissue, the conception of energy transfer by penetrating projectiles entails an understanding of the mechanisms of tissue disruption that is effected, rather than viewing the latter simply as the end result of random dissipation of kinetic energy.^{1,34,91} It should also be remembered that it is the proximity of the wound to vital organs that ultimately determines the severity and outcome of the injury.⁷²

Factors affecting the efficiency of energy transfer: the projectile-tissue interaction

When a bullet comes to rest within the body without deforming or losing its substance, its entire kinetic energy has been transferred into the tissues,^{8,45,92,93} where as when such a bullet perforates through the body, only part of its energy is used up in wound formation.^{12,31,46,86,93} In either case, the energy transferred is not always

Table 1. Projectile factors involved in wound ballistics.

Inherent ballistic properties

Mass: determines kinetic energy, inertia, penetration capacity

Calibre: normally of lesser importance; large calibres increase wounding effects

Kinetic ballistic properties (conferred by the weapon)

Velocity: determines kinetic energy, penetration capacity, drag

Kinetic energy: determines overall wounding power

Factors affecting drag profile and stability in tissue

Shape (round nose versus pointed 'spitzer' nose; boat tail versus flat base)

Construction (full jacketed versus semi jacketed; location of centre of mass)

Length

uniformly distributed along the wound track, nor is the resultant tissue damage,^{45,78,84,87,94,95} a fact most evident when an enlarged exit wound is opened.^{84,96} This is because, in addition to the different properties of the tissues, there may also be variations in the behaviour of the bullet itself along its path,^{87,91} as demonstrated by terminal ballistics in homogeneous tissue simulants, such as gelatin and soap.^{1,34,55,84} Therefore, besides the energy possessed by a penetrating projectile, what is important for the extent of wounding is the rate of energy loss in transit through the target tissue.⁹⁷ This is determined by drag, which is the force causing the retardation of the projectile.^{1,8,9,45,70,98} Impact kinetic energy and drag can be considered the two main descriptors of the projectile tissue interaction, which results in energy transfer to tissue.⁴⁵

Drag (F_D) is expressed in terms of the density of the surrounding medium (ρ), the cross sectional area of the projectile presented onto a plane perpendicular to its motion (presenting or frontal area, A), and its velocity (v), according to the equation $F_D = \frac{1}{2} C_D \rho A v^2$, where C_D is the drag coefficient.^{45,55,99-101} Because of the exponential effect of velocity on drag, the kinetic energy loss in tissue will be much greater with high velocity missiles.⁴⁵ At supersonic speeds, this effect becomes critically important, hence the 'spitzer' (pointed) contour of the forebody in modern military rifle bullets (Fig. 3), which affects the C_D in such a way that a very large drag is avoided.⁴⁴

However, the most complex implications occur due to changes in the presenting area of the projectile.⁹⁹ Whereas spherical missiles facilitate experimental

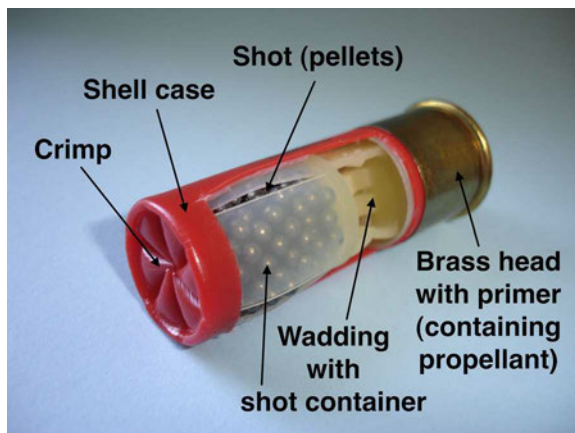


Fig. 6. 12 gauge shotgun shell (opened).

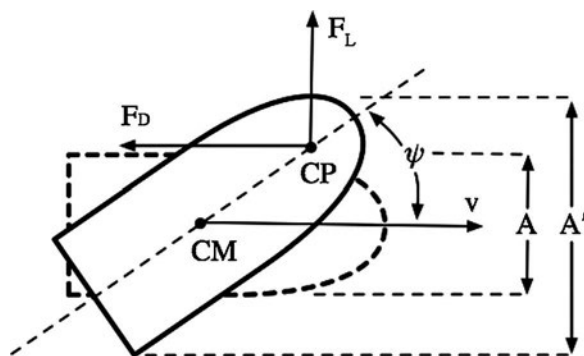


Fig. 7. Drawing of a yawing bullet with its centre of mass (CM) and centre of pressure (CP). The bullet in a point on orientation is depicted in the background (dashed line). Distances A and A' represent the presenting area of the projectile in flight, point on (A) and at yawing (A'). F_L = lift vector; F_D = drag; v = velocity vector coincident with the axis of flight; ψ = angle of yaw (exaggerated).

purposes as they offer a constant presenting area,^{33,92,102} bullets are designed to afford the minimum area of presentation with the maximum possible mass by their elongated body,^{74,89} which introduces the factor of stability to their movement.^{1,45,46,67,85} A stable bullet is one travelling 'nose on' with its axis always close to its trajectory described by its centre of mass.^{34,55} When this axis deviates from the tangent to the trajectory, the bullet's presenting area can only increase. This deviation is called yawing, expressed as the angle of yaw.^{29,33,44,45,81}

Yawing occurs around the bullet's centre of mass.⁷² A tendency to yaw is inherent to all bullets flying nose on,^{45,49,68,103,104} without representing in stability,¹⁰⁵ exaggerated immediately after the exit from the muzzle due to the destabilizing effects of the muzzle vibrations and the outburst of propellant gases.^{44,55,81,104,105} Available data for military weapons suggest that, at this point, the maximum angle of yaw is of the order of 5° – 6° (Fig. 2e).^{89,103} Any such deviation generates lift induced drag, which concentrates on the so called centre of pressure of the bullet, located in front of

its centre of mass. As a result, an overturning moment, most prominent in spitzer bullets, is created, which tends to destabilize the projectile (Fig. 7).^{33,38,45,99,101,106} This effect is gyroscopically counteracted by the high rate spin imparted by rifling.^{34,44–47,49,81,107} Spin stabilization, however, is not instantaneous, as the spin induces other variations in motion on a yawing bullet.^{45,46,56,100,103,108} As a consequence, the bullet nose describes in space a spiral of declining amplitude, which in its simplest form is known as precession,^{29,33,44,45,81,104,108} similar to the wobbling of a spinning top knocked sideways.^{34,38,81,100} Within a distance of 100 m, precession is damped and the bullet flies virtually nose on.^{38,46,49,81,89,105}

However, once the bullet enters the body it cannot maintain its previous orientation because the stabilizing action of spin is overcome by tissue density exceeding that of air by approximately 800 times or more^{33,45,47,55,56,72,89,109}; as soon as yawing begins, the overturning moment will further increase the angle of yaw by a positive feedback.^{45,70} A spin stabilized bullet becomes unstable if yaw exceeds

approximately 15° ,³⁸ and eventually it will tumble as the angle increases beyond 90° .^{1,56,106,108,110} Given an adequate distance of tissue penetration, tumbling appears as an integral part of the ballistic behaviour of modern military rifle bullets,^{55,77,84,106} following which they may continue travelling with reversed orientation presenting their base in front (Fig. 8).^{45,54,70,72} In the literature, tumbling is often overused as synonymous to excessive yawing.

Yaw in tissue has a major influence on the wounding process¹⁰⁵ because it involves a greater projectile area contact and severing more tissue.^{1,29,33,34,45,55,70,77,96} As the bullet approaches 90° of yaw, its entire length acts to effect tissue disruption in the extreme,⁴⁷ resulting in maximum energy transfer.^{1,29,91,96} As a result, a rifle bullet traversing soft tissue sideways at velocities above 600 m/s is also subjected to overwhelming stresses, which may cause flattening of the cylindrical body and even break up of the jacket, depending on the bullet's construction.^{45,70,109,111,112} The latter typically occurs at the level of the cannelure (a circumferential recess on the jacket into which the mouth of the cartridge case is crimped), with subsequent extrusion of the lead core.^{35,45,70,112}

Bullet fragmentation, once considered only the result of bone hits,⁶⁸ gained considerable medical attention following early reports from the Vietnam War,^{113,114} which mentioned tumbling of the M16 rifle bullet as an additional cause for its excessive wounding effects, previously attributed solely to its high velocity (about 940 m/s).^{74,75,77} It was revealed that fragmentation of that bullet secondary to tumbling in soft tissue follows a characteristic pattern,¹¹⁵ being the major wounding factor associated with its ballistic behavior.^{45,73,77,96} Previous experience from Northern Ireland also suggested an extensive nature of the wounds produced by the M16 rifle and its civilian version AR 15.^{80,116}

Bullet fragmentation is widely regarded as the culmination of the projectile tissue interaction, which enhances the dynamics of the penetrating trauma because the fragments produce multiple lacerations around the main wound track.^{34,80,96,117} However, a retrospective analysis of a large series of war wounds from the Red Cross database⁵⁸ concluded that bullet fragmentation is an unreliable indicator of wound severity, as it was present in only 7.9% of 'large' wounds, whereas it may also occur with less extensive injuries. The low incidence of this finding in 'large' wounds must be correlated to the

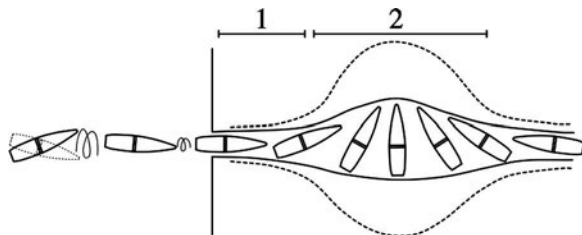


Fig. 8. Idealized ballistic performance of a military rifle bullet in air and through tissue. The bullet penetrates tissue from left to right. The wound track displays an initial narrow channel or neck (1), but subsequently widens owing to bullet yawing and tumbling (2). The temporary cavity causes radial expansion of the wound track in a spindle shape fashion, outlined at its maximum by the dashed line. Note that bullet tumbling, shown here within a short distance for illustrative purposes, normally requires a certain penetration depth. Note also the declining precession of the bullet in air, which intensifies upon entering tissue.

fact that most current designs of military rifle ammunition, including the AK 47 bullet of Russian origin and the current standard NATO M16 rifle bullet, do not fragment unless they strike a large bone.^{45,72,115} The association of bullet fragmentation with as much as 3.5% of those wounds not defined as 'large'⁵⁸ is less clear; since most of the examined wounds affected the limbs,⁵⁸ the results may have been influenced by bone hits resulting in bullet break up with less severe fractures that did not meet the criteria for 'large' wounds. For bullet fragmentation to occur, an additional amount of kinetic energy is spent, which is dissipated to the bullet itself rather than to the tissue.⁸⁶ Furthermore, when associated with bone impact, this finding exhibits different energy transfer characteristics than when occurring in soft tissue, not necessarily indicating high energy transfer (Fig. 9).

Unjacketed lead bullets fired from handguns usually do not break up, owing to their low velocity, although they may deform, particularly if bone is struck (Fig. 10).⁵ Expanding bullets that deform to a mushroom shape attain a much greater surface area of presentation. This results in higher energy loss early in the projectile path^{6,30,118,119} and a much greater amount of tissue crushed compared to that from a non deforming projectile travelling nose on.^{43,75} Expanding bullets do not yaw because mushrooming offers shoulder stabilization.⁷⁰

In general, increasing velocity enhances the penetration capacity of the projectile,^{9,34,45} but this is straightforward only up to the point where the also increasing drag forces begin to affect its form.¹²⁰ Subsequent deformation reduces its penetration potential in proportion to the resultant widening of its presenting area,^{6,43,120} but also because part of its kinetic energy is used in the deformation process.^{53,58,86} Because of this effect, a handgun bullet that mushrooms tends to be arrested within tissues, giving up all its energy, and this is the rationale for the use of expanding bullets in police weapons to reduce the risk of injured bystanders following over penetration of the intentional target.^{22,61} On the other hand, a non deforming rifle bullet can pass through a narrow target without significant yaw, thus producing a low energy transfer wound despite its high velocity impact.^{8,45}

Mechanisms of firearm-related injuries

During ballistic penetration of the human body, effective energy transfer produces direct as well as indirect tissue

A



B



Fig. 9. Fragmentation of a military rifle bullet following impact with the right malar eminence, which also had a dramatic effect in altering its trajectory (the bullet was removed through the pharyngeal wall). The wound was sustained in a war zone, with much of the bullet's kinetic energy spent as a result of an apparently distant shot, which explains the absence of significant bone injury. At radiograph (a), the jacket can be distinguished from the separated lead core (far right) by its open base resembling a hoop, a typical manufacturing characteristic of FMJ bullets. The jacket opened both at the level of cannellure and longitudinally (b).

damage.^{9,45,80} The importance and magnitude of each of these effects are determined by the characteristics of the projectile and the tissues involved.⁷³

Direct injury, sometimes called prompt damage,^{18,121} occurs as penetration is accomplished by a process of rapid distension followed by rupture of tissue by the projectile's leading edge, resulting in tissue laceration surrounded by

contusion.^{8,49} In the case of low energy wounds, such tissue damage is largely confined to the wound track,^{5,28,57,81} minimizing the need for debridement.^{4,32} However, when a projectile penetrates at high velocity, extremely high hydrodynamic pressures develop in the immediate vicinity,¹²²⁻¹²⁵ producing a more substantial crushing component of direct tissue damage.^{82,124} Moreover, two other highly



Fig. 10. Deformed handgun lead bullet retrieved transorally from the right masseteric area of a police officer. The deformation was due to impact upon the ipsilateral mandible.

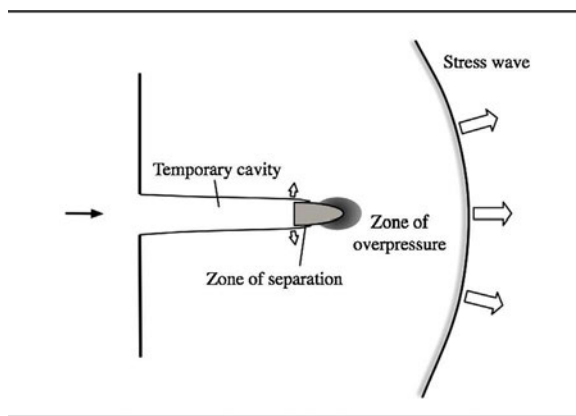


Fig. 11. Pressure phenomena set off by a bullet penetrating tissue at high velocity: at the point of impact, a stress wave is formed, which rapidly spreads ahead without actual tissue movement; secondarily, separation at the projectile tissue interface results in temporary cavity formation behind the bullet.

dynamic pressure phenomena appear (Fig. 11),^{9,70,122,126,127} responsible for in direct injury without contact between tissue and projectile.^{1,45,57,80}

Initially, a pressure wave of roughly spherical form propagates from the very point of impact forwards, with approximately the velocity of sound in water (1500 m/s), thus leaving the retarded projectile behind.^{9,46,55,61,70,81,122,123} Although often considered as a shock wave, this is more properly referred to as stress wave^{1,5,11,45} or ballistic pressure wave.⁹⁷ Despite their intensity,^{9,61,70,122} the ability of stress waves to cause tissue injury has been disputed,^{1,5,35,75,77,128} based on their short duration and the lack of tissue movement or macroscopic tissue damage.¹²² However, bursts of stress waves of much longer duration have been recorded in live animal models,¹²⁹ associated with reflection and diffusion of the primary disturbance by heterogeneous body parts.^{9,45,61,123} By this mechanism, susceptible interfaces of differing acoustic impedance can be damaged,^{11,130}

accounting for the capillary endothelial and blood brain injury previously reported in animals.¹²⁹ More recent research suggests that stress waves may induce microscopically apparent damage to the nervous system,¹³¹ particularly to the brain.^{132,133} Probably of greater importance in causing cell damage are the concomitant abrupt changes between high positive and negative pressures.^{61,92}

In a second phase, the previously static tissue is forced to detach itself at some point from the surface of the advancing projectile by flow separation.^{55,99} This phenomenon, which is characteristic of flow past an object that is not sufficiently streamlined, becomes conceivable when the tissue material is viewed as 'flowing' backwards with respect to the projectile. Because of the existing pressure gradients,^{92,130} separation rapidly proceeds to expansion of the wound track, which may be out of proportion to the bullet's dimensions, culminating into what is known as a temporary wound cavity.^{9,33,55,70,122,123} This important biological effect has the

potential for inflicting injury beyond the confines of the wound track,^{1,35,55,75} considered the main mechanism whereby high energy missile wounds are produced.^{46,49,57,70,123}

Temporary cavitation

The formation of a cavity of transient character by the projectile^{134,135} is a dynamic process of very short duration, involving radial tissue displacement associated with secondary pressure changes.^{55,61,70,122,127,130,136} This is considered the result of momentum imparted to soft tissues particles, which are then accelerated en masse at right angles to the direction of its trajectory creating a void.^{9,11,33,45,55,65,122} The cavity significantly lags behind the missile due to the inertia of the tissues displaced,^{45,46,53,80-82,108,134,135} reaching maximum size within approximately 1 ms after its passage.^{9,45,89} Thereafter, tissue elasticity causes the cavity walls to pulsate in a violent waning fashion and eventually collapse,^{9,33,45-47,55,134} hence the name temporary cavity.^{67,81}

The maximum volume of the temporary cavity is related to the amount of kinetic energy transferred by the projectile in combination with the elastic properties of the tissues,^{1,9,55,137,138} whereas its cross sectional area at any given point depends on the local drag force.^{55,92,137} The relationship of cavity volume to the energy expended has been demonstrated by Harvey et al.⁹ by means of two spheres of different masses fired through the thighs of cats; with striking velocities adjusted so that measured energy losses were approximately the same for both spheres, the volumes of the temporary cavities produced were approximately equal.

Cavitation is to some extent a feature of almost all missile wounds,^{5,6,81,134,136,139} but its clinical significance depends on the size of the cavity and, most importantly, the characteristics of the tissue involved.⁷⁵ The temporary cavities induced by low velocity bullets are not large enough to cause significant injury except in sensitive tissues,⁷² particularly the brain.¹⁴⁰⁻¹⁴³ Cavity formation becomes clinically important usually at striking velocities exceeding 300 600 m/s, beyond which the cavitation changes become much more marked.^{45,80}

The mechanism of tissue damage by cavitation is usually summarized as radial stretching^{66,77}; it may extend over a wide area subjected to peripheral compression by the expanding cavity, also involving shearing effects related to tissue

heterogeneity.^{3,7,66,73,75} Inelastic organs such as the liver are far more susceptible to disruption than skeletal muscle,⁷ which can tolerate better the cavitation effects as long as there is no circulatory impairment or uncontrolled infection.^{5,34,77,78,81} Within the confines of the skull, the pressure built up due to cavity formation by rifle bullets is usually devastating for the brain.^{11,46,49,66,127} With projectiles penetrating at very high velocities, the skull bones may be blown apart.^{9,31,46,66,70} Such an explosive effect is not seen on empty skulls, indicating the necessity of a medium with fluid properties for the development of high pressure phenomena.⁹

Projectile shape, construction, and stability play a greater role in determining both the size and location of the temporary cavity than velocity alone.⁴⁵⁻⁴⁷ Modern military type rifle bullets appear to cause minimal disturbance in tissue as long as they are travelling nose on, due to their low drag profile.^{47,55,75,85,137,144} However, their tendency to yaw has a dramatic effect on cavitation because of the separation phenomena induced by a yawing bullet.⁹⁹ Accordingly, the peak of the temporary cavity produced by a non deforming bullet is not close to the entrance where it still has highest velocity, but rather at the point where it turns sideways.^{1,34,47,55,96} Large temporary cavities in animal wounds have been reported with small calibre military ammunition from the M16 rifle, attributable to a combination of high velocity and bullet tumbling.⁹⁶

The penetration distance before the yaw cycle commences corresponds to an initial segment of the wound track, termed narrow channel or neck,^{66,70,109} which is demonstrable in tissue simulants preceding cavity expansion (Fig. 8).^{1,54,55} The length of the narrow channel differentiates the performance of various military rifle bullets,^{1,60,106} as it is a measure of the bullet's stability in soft tissue, which in turn affects its wounding effect.^{96,115} This distance typically varies between 15 and 25 cm,^{35,54,75,109} but it is considerably shorter for the M16 as well as the newer Russian AK 74 rifle bullets.^{75,96}

A recent study¹⁴⁵ raised doubts about the universal validity of these estimations, which are based on the measured residual deformation of gelatin^{111,146} and soap ballistic models.^{54,70} Using flash X ray radiography, the authors demonstrated large irregular temporary cavities in human cadaver thighs penetrated through muscle by two types of military rifle bullets. They also reported that cavitation by 7.62 mm bullets occurred in the absence of significant yawing, although they did not provide

measurements of the projectile path.¹⁴⁵ However, because of the strong dependence of bullet yawing and the resultant energy transfer on wound channel length, this quantity must be accurately measured when flash X ray imaging is used, especially where considerable variation is expected.^{33,86} In addition, cadaveric soft tissue may not adequately reflect the cavitation changes occurring in the living.⁷⁰ Nevertheless, the differences in cavitation phenomena observed in humans or animals from those developed in tissue simulants are currently an active area of research.^{99,147}

With expanding bullets, the temporary cavity displays a different pattern. These bullets are associated with almost immediate cavitation without a narrow channel component, because of the deformation resulting in maximum drag and energy transfer at an early point.^{6,54,70,118} The cavity produced is also markedly increased in size,^{47,49,54} and a deforming bullet from a powerful handgun may produce localized 'high energy' effects, comparable to those seen with the much faster assault rifle bullets.^{6,82} An FMJ bullet that has ricocheted becomes unstable, also creating a temporary cavity immediately after impact.⁷⁰

Vascular damage from temporary cavitation can be extensive. Capillaries and small blood vessels are mainly affected, resulting in areas of focal bleeding.^{9,49,80,81,122,135} Large vessels not severed by the bullet tend to escape gross injury as they are pushed aside due to their elasticity,^{9,49,81,108,135} although endothelial injury and thrombosis may still occur.^{4,5,45,94,108} However, even large arteries may be torn apart by the stretching mechanism.^{10,148} Nerve trunks stretched by cavitation without breaking may lose function, usually temporarily.^{9,41,45,81,135}

When cavitation is associated with missile or bone fragmentation, the result is usually severe.^{5,96} Bullet fragmentation causes lacerations susceptible to subsequent disintegration by the stretching of the temporary cavity.^{69,117,149} This synergistic mechanism of tissue disruption may account for the creation of large exit wounds by high velocity projectiles.⁴⁷

Shotgun injuries

The severity of shotgun injuries is determined by the range and the shot pattern.^{31,32,62,64,93} At close range (less than 3 m), the shotgun produces the most devastating injuries of all small arms,^{25,28,31,41,72,150} because the pellets are still tightly clustered, without significant

reduction of their muzzle velocity of 350 400 m/s.^{72,93} Under these circumstances, the wound appearance is primarily determined by gauge rather than pellet size, as the entire shot tends to function as a single large missile.^{23,72,93,151} At ranges up to 7 m, wadding material should also be suspected to be lodged in the wound as radiolucent foreign bodies.^{11,23,62,64,72,93}

Because of their non aerodynamic shape, the spherical pellets slow rapidly in flight and their wounding capacity drops significantly with distance,^{31,63,93} whereas the shot also spreads out,^{62,63} causing multiple discrete wounds determined by the pellet size.^{32,62} Beyond 10-12 m, superficial wounds are usually inflicted,¹¹ and clothing may further reduce the penetration capacity of individual pellets.

Shotgun slugs produce massive internal injuries within a range of 100 m, comparable in severity to those encountered from hunting rifle bullets.^{31,32,63} Temporary cavities play no significant role in shotgun injuries except for those inflicted by slugs.^{31,32}

Pathological and morphological characteristics of bullet wounds

The visible or palpable wound track produced by a bullet is known as the permanent wound cavity. It consists of a wound of entrance and, if the projectile has perforated the body, a wound of exit.⁷³ Accordingly, the wound may be penetrating ('blind') or perforating ('through and through').^{23,150}

In skeletal muscle, the permanent cavity is surrounded by an area of cellular and endothelial damage,⁹⁵ the gross appearance of which is that of bruised tissue.¹⁴⁹ Microscopically this area of contusion, also known as the zone of extravasation,^{5,89} contains haemorrhagic, non viable tissue bearing the typical histopathology of necrotic myocytes,^{45,82,95} the innermost layer of which may eventually slough becoming part of the permanent cavity.^{45,149,152} The contusion zone is surrounded by a "concussion zone" characterized by grossly normal muscle with histological evidence of potentially reversible damage.^{45,82,95} In brain injuries, the contusion zone roughly corresponds to an inner zone of astrocyte destruction surrounded by a bleeding zone; a wider outer oedematous area is marked by axonal and neuronal injury.^{142,153}

Bullets are not sterilized by the heat of firing; they carry bacteria from the gun barrel, clothes, skin, and mucosal surfaces into the wound,^{35,81,94,154-157} which subsequently colonize tissue. An important aspect of temporary cavitation is the active

Table 2. Summary of bullet behaviour in tissue.

Bullet type	Penetration capacity	Yawing/tumbling	Fragmentation	Mushrooming	Temporary cavitation
Non deforming (FMJ)					
Handgun	Great	Limited yawing	No	N/A	Small to moderate cavity
Rifle	Over penetration	Tumbling	After bone impact ^a	N/A	Large cavity, maximum at 90° of yaw
Expanding					
Handgun	Limited	No	After bone impact	Yes (with sufficient velocity)	Moderate to large cavity near entrance (coincident with mushrooming)
Rifle	Over penetration	No	At high velocities or after bone impact	Yes	Very large cavity near entrance (coincident with mushrooming)

FMJ, full metal jacketed; N/A, not applicable.

^a Fragmentation occurs in soft tissue with some lead core copper jacketed military rifle bullets at striking velocities above 700–900 m/s.^{111,117}

contamination of the wound by foreign material aspirated through the entrance and, if present, the exit site, owing to the sub atmospheric pressure within the expanding cavity.^{34,81,155–158} Further more, shearing effects of cavitation may separate tissue planes¹⁴⁹ allowing the spread of contamination.¹⁵⁹ This results in a large amount of dead tissue inoculated with bacteria and debris from the surface, which represents the specific pathology of the high energy missile injury.^{46,55}

Tissue disruption and damage are most extensive where energy transfer has been greatest, which is close to the entrance for non aerodynamic projectiles, while with non deforming bullets this occurs deeper within the wound, concurrent with yaw growth.^{96,144,152,160} Perforating wounds by military rifle bullets in the hind legs of anesthetized animals have been shown to heal uneventfully in the absence of bony and major vascular damage,⁷⁸ provided that free drainage of necrotic tissue is established through the exit wound.¹⁶¹ On a microscopic level, necrosis appears to progress for up to 6 h after wounding, following which inflammatory changes and possibly infection predominate.¹⁵² These observations indicate that, unless heavily contaminated, well perfused muscle surrounding the wound track remains largely viable. This includes uncomplicated soft tissue wounds inflicted by modern military rifle bullets, thereby requiring only minimal wound excision.^{34,82,162,163} However, ischaemia may contribute to a more prolonged course of tissue necrosis, in addition to the delayed effects of the initial trauma.^{80,164}

The permanent wound cavity, presumably the most important aspect of wounding,^{41,125,165} is mainly the result of tissue crushing¹¹¹ rather than tissue expelled. Its size increases by any supervening bullet

expansion, yawing or fragmentation,^{111,116,166} but it is also influenced by the magnitude of the preceding temporary cavity depending on the elastic recoil of the tissues.^{45,81,82} The effect of bullet calibre in soft tissue wounding has little importance from a surgical point of view.^{35,80} Expert opinion suggests that the wounds produced by handgun bullets of various types usually cannot be differentiated at autopsy¹¹⁹; this may not apply to wounds caused by larger bullets, such as the .45 calibre, for which moderately greater wounding effects in animal tissue have been reported.⁷⁸

The external appearance of the gunshot wound may be one of three general types.^{162,167} The typical entrance wound consists in a punctate type circular defect approximately the same diameter as the bullet. The second type of wound is characterized by a stellate appearance created by skin splits but not tissue loss. The third type of wound is the avulsive injury characterized by tissue loss, usually produced by close range shotgun blasts.

Military rifle bullets invariably exit the body, except when fired from a distance.^{18,31,43,61} Although a stellate exit wound indicates high energy transfer as a result of temporary cavity expansion near the exit site,^{10,55,82,96,138,152} the less common scenario of a punctate exit wound does not necessarily suggest the opposite, particularly in the case of a long wound track, which may conceal a deeper area of serious tissue disruption.^{1,13,55,75,138} Sometimes, handgun injuries may also present with larger and irregular exit wounds, most likely due to bullet tumbling.^{10,18,31,116} Expanding rifle bullets produce massive injuries with enormous exit wounds.^{31,43}

In conclusion, the current classification of missile injuries into low energy and

high energy ones correlates the degree of tissue damage with the amount of energy transferred by the penetrating missile. Although the velocity of the projectile is a major determinant of its striking kinetic energy, the proportion of that energy resulting in wound production is determined by the degree of retardation of the projectile, influenced by its presenting area and the density of the target tissue. Expanding bullets undergoing deformation upon impact, and non deforming bullets, generally offer two different models of energy transfer based on their drag profile (Table 2). High energy ballistic trauma is characterized by substantial tissue damage beyond the wound track created by the projectile, as a result of the formation of a large pulsating temporary cavity, which also contributes to wound contamination. These wounding effects, however, are of lesser extent compared to the distinctively massive injuries produced by shotgun blasts.

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Patient consent

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EXHIBIT 34

New York Police Department Is Retiring the Revolver

About 50 officers still carry the storied six-shot revolver that became the standard department firearm in 1895, but the weapon is being phased out.

By Ashley Southall

May 31, 2018

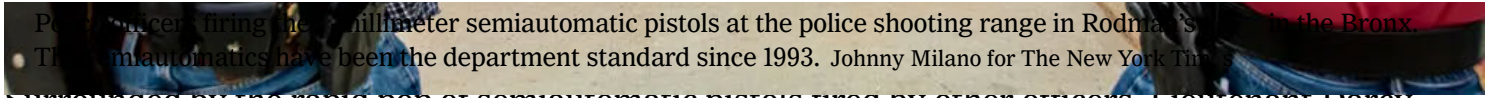
3 MIN READ

Plenty of things have changed about the New York Police Department since Lt. James Darcy joined in 1987. Until now, the service weapon swinging at his hip, a .38-caliber Ruger Service-Six, has not been one of them.

The gun, a blued steel revolver with diamond-shaped etching on its curved wooden handle, became popular after it was introduced in the 1970s, but it will soon go the way of the wooden nightstick. Lieutenant Darcy, 54, who patrols public housing in Queens, is one of about 50 officers who are required to retire their service revolvers by the end of August as the Police Department parts ways with the handguns that defined policing for a century and that bestow gravitas on the officers who still carry them.

“It feels sad,” he said on Wednesday at the police shooting range in Rodman’s Neck in the Bronx, where he was training on a new Sig Sauer sidearm. “I really love my gun. I really never thought I would leave the job without it by my side.”





surrounded by the rapid pop of semiautomatic pistols fired by other officers, Lieutenant Darcy squatted on the firing line as he drew his revolver, a relic that harked back to a time before gun violence in America reached epidemic levels and spurred the Police Department and most other law enforcement agencies to switch to semiautomatic weapons.

By late morning, Lt. Darcy was standing on another firing line with 25 officers who also carried the six-shot revolver during some of the city's most violent years. But now they were all holding the 9-millimeter semiautomatic pistols that have been the department standard since 1993, when they were adopted to help combat the perception that officers on the street were outgunned by criminals.

By then, the police were confiscating more semiautomatic guns from crime scenes and several police officers across the country had been killed in gun battles while reloading their revolvers. One was Scott Gadell, a rookie who was killed chasing a suspect on foot in June 1986 in Far Rockaway, Queens.

Although police shootings have declined over the years and most officers never fire their weapons in the line of duty, officials said it was still necessary to complete the transition to semiautomatic weapons in a policing era where terrorism and active shooters are omnipresent threats.



Officer Timothy Broadus, left, loading the magazine for his newly issued Glock, and Lieutenant Darcy, right, his beloved revolver. Johnny Milano for The New York Times

"After this class, the days of seeing a police officer out there carrying a swivel holster or a .38 holster with a .38 in there are basically nonexistent," Inspector Richard G. DiBlasio, the commanding officer of the Firearms and Tactics Section, said. "It's tradition and some people don't

want to let go of it, but tactics is always number one.”

Revolvers became the standard firearm for city police officers in 1895, and they remained the dominant weapon in policing for much of the 20th Century. More than 2,000 city police officers still held on to the revolvers over a decade after Sig Sauer and Glock pistols became standard. Their numbers dwindled with each wave of retirements, to 160 by the time the Police Department announced in November that it was phasing out revolvers completely and permanently.

But the change has been met with resistance from officers reluctant to set aside the revolvers that they regard as old friends for unfamiliar pistols that have twice the capacity but are susceptible to jamming. Officer Mary Lawrence, a crime prevention officer in the 103rd precinct in Queens, said that was never a concern with the Smith & Wesson revolver that she has used over her 26 years with the department.

“I’m proud of this uniform that I’m wearing and I’m proud of my gun that I carry because it’s been reliable to me,” she said. “I didn’t think that I needed extra firepower at all.”



Police Officer Mary Lawrence and Sgt. Steve Ward getting targets to set up for training at the Police Department at Rodman's Neck in the Bronx on Wednesday. Johnny Milano for The New York Times

The move away from pistols is one of a sea of changes in the Police Department. Sgt. Thomas O. McLaughlin, who works in the Bronx Homicide Squad, marveled at how inventions like computers and smartphones replaced pay phones and typewriters in what seemed to him like “the flash of an eye.”

“All this in the past 25 years is amazing,” he said. “It’s sad, too, in a way because we’re leaving behind a lot of history of the department.”

Their reluctance aside, the officers concede that events like the school shooting in Parkland, Fla., offered signs that it was time to move on.

But Officer Timothy Broadus, who joined the force in 1990 and works in the 84th Precinct, said he knew it was time to make the switch when someone asked about his revolver: ““Do you got to put powder in that thing to make it work?””

He does not.

EXHIBIT 35

The New York Times

<https://www.nytimes.com/1989/03/12/nyregion/police-turning-to-9-mm-guns-to-fight-crime.html>

Police Turning to 9-mm. Guns to Fight Crime

By Amy Hill Hearth

March 12, 1989

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MANY police departments in Westchester may soon join the ranks of law-enforcement agencies nationwide that are replacing the time-honored .38-caliber revolver with a 9-millimeter semiautomatic pistol as a standard weapon. The change comes primarily because of mounting evidence that criminals - especially drug dealers - are better armed than ever.

The police in Yonkers, the city of Rye, the village of Ossining, the town of Harrison and the village/town of Mount Kisco are among those expected to make the change before the end of next year. Police officers in Ossining will start carrying the semiautomatic in a matter of weeks. The transition is not a speedy one. Police departments must decide what models they prefer, arrange the financing and provide special training sessions for their officers.

Police departments testing different models of 9-millimeter semiautomatics include the County Department of Public Safety. The village of Tarrytown and the White Plains Police are determining if there is a need to change handguns.

The two weapons are roughly equivalent in power, but the primary advantages of the 9-millimeter semiautomatic pistol are that it can fire up to 19 bullets without reloading, and reloading is as simple as replacing a "clip" or magazine. A .38-caliber police revolver ordinarily has six cartridges, which must be replaced individually. (Some police departments also use a .357-magnum revolver with .38-caliber cartridges.) There have been several recent cases in the United States of a police officer being killed during a gun battle by an assailant using a semiautomatic while the officer was trying to reload a .38-caliber

revolver. In Yonkers, on Feb. 13, three shots were fired at two police officers by a man armed with a 9-millimeter semiautomatic. The officers were not injured but the incident gave credence to local officers' fears of being "out-gunned." What Confiscations Show

Some police departments - particularly Yonkers but also in the city of Rye, for example - have been confiscating more semiautomatic weapons at crime scenes and from criminals. A Yonkers Police Department study headed by Capt. Robert Taggart showed a 55 percent increase in the number of semiautomatic weapons confiscated there from 1986 to 1988.

Other police departments have less substantial evidence that their .38-caliber revolvers may no longer be sufficient, but are considering a change to the 9-millimeter semiautomatic because they feel the weapon is superior and that it makes a visible statement to would-be criminals.

A few police departments, including those in the town of Bedford and the village of North Tarrytown, have for several years allowed their officers the option of choosing to buy a 9-millimeter semiautomatic weapon for on-duty use, providing that they receive permission and special training.

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North Tarrytown, with 27 police officers, plans to continue this arrangement, said Lieut. James P. Brophy, the acting chief. In Bedford, where about one-third of the 37 officers have chosen to use a 9-millimeter semiautomatic on duty, a departmentwide move to the semi-automatic is "under consideration," Lieut. Ted Wyskida said. The Ossining Police Department, which said it planned to provide 9-millimeter

semiautomatics for its officers this year, might allow veteran officers the option of continuing to use their .38-caliber revolvers, Lieut. Joseph Burton said.

The Yorktown police last year established an emergency-services unit made up of 10 officers who are scheduled to get 9-millimeter semiautomatics this year, Capt. William M. Calcutti said. The Peekskill police are taking the same approach by acquiring five 9-millimeter semiautomatics for special uses, Lieut. Frank W. Murnin said. The Factor of Confidence

Officers on patrol who are carrying the 9-millimeter semiautomatic say they feel better prepared for trouble. "I'm much more confident with a semiautomatic pistol versus a revolver," said Sgt. James P. Murphy, chief firearms instructor at the Bedford Police Department, who is on patrol part-time.

But the use of 9-millimeter semiautomatic weapons by the police - especially as a standard weapon for patrol officers - has encountered criticism.

Dorothy L. DiCintio of Scarsdale - whose brother, United States Representative Allard K. Lowenstein of Long Island's Fifth District, was murdered by a handgun-wielding assailant in 1980 - is one of Westchester's most active handgun-control advocates. She is a member of Handgun Control Inc., a Washington-based national organization.

"I understand the point of view of the police but it's the kind of thing that escalates," she said. "My view is that the proliferation of guns in any way, shape or form is bad. The more that are out there, the more that are used. It's terribly risky to have more semiautomatics out there, even in the hands of the police. Certainly, more innocent people will get hurt."

The police say that they are sensitive to this concern and that the solution is proper training, which would be mandatory for all officers. In Rye, for example, training would include a "re-emphasis" of the circumstances in which an officer may use deadly physical force, said Police Commissioner Anthony J. Schembri, a lawyer who teaches a course on corruption and integrity in government at the Pace University Law School.

"I wish to make it absolutely clear that simply because they would have more firepower does not give officers carte blanche authority to fire at people," Mr. Schembri said. "We are still under the same legal constraints." Change Awaited in Rye

Police Commissioner Schembri said he expected that his 36 officers would be using 9-millimeter semiautomatics next year. The change requires approval by the Rye City Council, but he said he saw "no reason" why it would not vote its approval.

In Yonkers, City Manager Neil J. DeLuca has accepted the recommendation of the police commissioner, Joseph V. Fernandes, to replace the .38-caliber revolver. Pending approval by the Yonkers City Council, which Mr. DeLuca said he anticipated, the changeover will be phased in. By next summer, every Yonkers police officer should have a 9-millimeter semiautomatic, Mr. DeLuca said.

The cost of upgrading the weapons in Yonkers will be about \$600,000, Mr. DeLuca said. That will include guns, holsters, ammunition and the initial training for the department's 530 officers. The old weapons will be returned to the manufacturer for refurbishing and sale.

Cost is a factor for most police departments considering the replacement of weapons. If the County Department of Public Safety decides to buy 9-millimeter semiautomatics, it may use funds from an interesting source.

According to the department's commissioner, Anthony M. Mosca, those funds mostly come from confiscations in narcotics cases.

Apparently, there are few police departments that prefer a weapon other than the .38-caliber revolver or 9-millimeter semiautomatic. But the Pound Ridge police, a five-man department that supplements protection by the New York State Police, carry a Smith & Wesson .45-caliber semiautomatic. Police Chief Craig A. Jorgensen, formerly a senior firearms instructor with the state police, said it was a superior weapon.

Dobbs Ferry made the unusual move, in 1985, of going back to the .38-caliber revolver after three years of carrying 9-millimeter semiautomatics. "We were experiencing difficulty with jamming," Police Chief Kevin J. Costello said, reiterating a common criticism of the semiautomatic weapon. But he added that he believed the newest models being considered for purchase by other departments had been improved, a contention nearly all officers agreed with. The View in New York City

Westchester police departments that may replace the revolver would be among hundreds of law enforcement agencies nationwide that have already made the transition to the semiautomatic. The New York State Police are expected to switch to semiautomatic handguns within two years.

One of the few police departments that plans to stay with the .38-caliber revolver is New York City's force of 28,000, where fewer than 1,000 officers - mostly detectives or members of special narcotics units - use a 9-millimeter semiautomatic, said Capt. John C. Cerar, commanding officer of the firearms and tactics section.

"In a typical situation, a 9-millimeter semiautomatic is not necessary in New York City," he said. "A gunfight is atypical. I'd rather train my officers to shoot better with what they have."

Captain Cerar conceded that some smaller police departments might see a need for the 9-millimeter semiautomatic because back-up units during a shootout were not readily available.

"The officer on the street should have a state-of-the-art weapon," said the Ossining Town Police Chief, James J. Krebs, whose 11-man department will start training soon with 9-millimeter semiautomatics that have already been purchased. "Our gun-related incidents have been minimal, but I like to think of it as an insurance policy," referring to the new weapon. Still Behind the Dealers

But the 9-millimeter semiautomatic pistol may itself be no match for drug dealers. The Yonkers police have confiscated several fully automatic machine guns. Even the Yorktown police in northern Westchester have confiscated at least one Uzi, a popular weapon among drug traffickers that is manufactured in both semiautomatic and fully automatic models.

"We'll still be two steps behind the drug dealers even with the 9-millimeter," said Chief Krebs of Ossining.

That is why many police officials say they have no choice but to replace the .38-caliber revolver that long has been the policeman's favorite. As Chief Krebs said:

"We have to give our guys a fighting chance."

EXHIBIT 36

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HOW TO REDUCE SHOTGUN RECOIL

January 17, 2023 | By Brandon Maddox



Shotguns are the third most popular firearm type in the U.S., and **more than half of American gun owners own a shotgun**. The firearm is a favorite because it is suitable for hunting various prey and intimidating and powerful enough for home or self-defense. On the downside, the typical shotgun has more recoil than most handguns and rifles.

Fortunately, you have several ways to reduce shotgun recoil to improve your handling and accuracy, and we will tell you the best ones. However, before sharing our top shotgun recoil

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May 9, 2019 | By Brandon Maddox

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Recoil is when you fire a round, and your firearm jerks backward. It's unavoidable if your firearm combusts propellant to launch rounds from the barrel, and what causes it is simple. Pulling the trigger releases the firing pin, which strikes the primer and ignites the propellant.

The propellant explodes and releases gases that expand and drive the bullet through the barrel and out the muzzle. The force with which the bullet and expanding gas explode from the muzzle will shove the firearm backward, which is what you experience as recoil. While recoil intensity varies between guns, you can expect more recoil when shooting rounds with a higher bullet velocity.

RECOIL V. KICK

You can use recoil and kick interchangeably, but from a technical perspective, the terms have slightly different meanings. Recoil is when a gun jerks backward due to the explosive force that sends a fired round out the muzzle. On the other hand, kickback or kick is the energy transmitted back to the shooter from a fired gun. In simpler terms, kick is the pressure you feel from the butt of your gun when you fire a round.

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and shock their faces. Such incidents occur

because the shooter cannot handle the shotgun recoil. Even if you can fire a shotgun and retain your grip, the force of the recoil jamming into your body can hurt and throw off your aim.

Fortunately, shooting your shotgun does not have to be a painful or embarrassing experience. Learn how to reduce shotgun recoil with these tips:

REDUCE GUN RECOIL WITH A SUPPRESSOR

Arguably the most convenient and effective shotgun recoil reduction tactic is to use a suppressor. Suppressors or silencers are barrel-shaped attachments that go on a gun muzzle. The attachment slows the escape of the expanding gas that explodes out of the gun, reducing the back pressure you experience as recoil.

Slowing the release of the expanding gas also muffles gunfire, making suppressors an excellent solution for making firing your shotgun less noisy. **Shotgun suppressors** come in various sizes, and the best quality ones can make shooting a 12-gauge shotgun a far less painful experience.



BRANDON MADDOX
CEO

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You will likely feel the recoil more if your shotgun is too bulky or long. Fortunately, you don't need to replace your shotgun. Instead, you can learn how to fit a shotgun correctly and significantly reduce your felt recoil.

If the shotgun is too long, holding it correctly to pull the trigger and **manage recoil** will be a problem. Also, a too-high or short stock will make holding the stock against your cheek difficult and worsen the felt recoil.

SHOTGUN FITTING BASICS

Before learning how to hold a shotgun to reduce recoil, verify that your firearm fits your body. A shotgun with the right fit will have a convenient length, stock height, and length of pull. The shotgun will fit snugly to your body and have an adjustable comb that you can modify.

It will also have a comfortable length of pull. If the length of pull is too long, holding the stock and firing the shotgun will feel clumsy and likely hurt your shoulder. You have the right fit when you can comfortably lay your cheek against the comb, sit the butt into your shoulder pocket, and center the shot pattern.

CHOOSE THE RIGHT AMMO

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gauge shotgun, opt for a 20-gauge that shoots smaller ammo and has less recoil. Recoil is even less when you shoot 28-gauge ammo.

Alternatively, opt for low-recoil **shotgun ammo**, such as ammo with a lower bullet velocity or feet-per-second (FPS) rating. A bullet rated over 1,200 FPS typically has a more aggressive recoil. You can easily find lower-rated shotgun bullets with the velocity or FPS rating clearly written on the box.

ADD WEIGHT

If you fire the same ammo from a heavy and lighter shotgun, you will feel the recoil more with the lighter shotgun. Why? Heavy guns absorb more of the recoil, dampening and lowering the recoil before it transfers to your body.

Fortunately, you don't have to throw away your light shotgun and buy a heavier one. You can make your light shotgun heavier and minimize recoil by attaching barrel weights. For instance, adding 25% more weight to your shotgun can reduce recoil by about 20%.

However, you have to distribute the added weight evenly across your shotgun. If you place too much weight on one part, it might ruin the balance of your firearm and spoil accuracy.

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are available for improving safety, accuracy, and comfort when shooting your shotgun. However, among all the shotgun recoil reduction tips, the most convenient and effective is to use a suppressor. Attaching one to your shotgun is quick and easy and reduces felt recoil significantly.

Even better, a suppressor doesn't just reduce felt recoil. It also muffles gunfire to protect your ears and hides muzzle flash to protect your sight when shooting in low-light conditions. Do you need help finding the best suppressor for your shotgun?

[Order a Silencer Central shotgun suppressor](#), or [contact us today](#) to speak with a friendly suppressor expert that will guide you toward your best choice.

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EXHIBIT 37

Gunshot Wound Review

Dr Fackler is president of the International Wound Ballistics Association.

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Martin L Fackler, MD

There is no serious argument about the wounding potential of various kinds of penetrating projectiles. The laws of physics in concert with modern bullet testing have clarified and quantified the mechanisms by which bullets disrupt tissue. Despite this scientific background, much misinformation persists in the wound-ballistics literature. This article reviews the interaction of penetrating projectiles with human tissue. Understanding of wound ballistics allows the emergency physician to become a more informed reader of its literature, as well as a more reliable provider of care to the wounded patient.

[Fackler ML: Gunshot wound review. *Ann Emerg Med* August 1996;28:194-203.]

INTRODUCTION

From the Revolutionary War to the settling of our western frontier, small-arms use has been inextricably entwined with American history. Widespread use of firearms has induced scientists and physicians to define the basic principles of wound ballistics. Over the past century, the mechanisms by which penetrating projectiles injure living tissue have been extensively studied and explained. Yet mistaken ideas about bullet effects are still held today. The most common misconception about gunshot wound treatment is that the penetration of any "high-velocity" bullet causes enigmatic "shock waves" and cavitation that will doom tissues even far from the bullet path. The purpose of this review is to scientifically discuss wound ballistics, refute misconceptions, and present the pathophysiology to support a rational strategy for the treatment of gunshot wounds.

CONTROVERSIES REGARDING WOUNDING POTENTIAL

In 1967, a group reported the wounds caused by M-16 rifle bullets in Vietnam as "massively destructive"¹ and possessing "devastating wounding power . . . tremendous wound-

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Fackler

ing and killing power".² Because the 3,100 foot/second (945 m/second) muzzle velocity of the M-16 bullet was higher than that of previous military bullets, "high velocity" became synonymous with "devastating wounding power."

These subjective descriptions attracted the attention of Swedish researchers.³ In 1974, a Swedish wound-ballistics researcher claimed that the tissues surrounding wounds caused by "high-velocity" projectiles were "subjected to the formation of the temporary cavity [which was] 30 times the diameter of the projectile" and that these tissues "will not survive."⁴ Implicit in this claim was that in the treatment of any wound caused by a "high-velocity" projectile the surgeon must excise a cylinder of tissue at least 30 times the diameter of that projectile: To treat a wound caused by a 30-caliber bullet (such as that fired by the AK-47 "assault rifle"), a surgeon would have to carve out a cylinder of tissue at least 9 inches in diameter. This procedure equates to performing amputation for practically any wound of the arm or leg.

Others have also claimed that assault weapon bullets cause massive injuries, including traumatic amputation.⁵ In addition, many fallacies regarding bullet effects were presented in the 1975 edition of *The NATO Handbook: Emergency War Surgery*, including a description of the temporary cavity for "high-velocity missiles" as "30 to 40 times the size of the missile."⁶ Although the Swedish findings were subsequently disproved³ and a new objective and scientific chapter on missile-caused wounds was written for the 1988 edition of *The NATO Handbook*⁷, widespread misinformation persists.

Delegates to the Tri-Service War Surgery conferences of 1970 and 1971⁸ reported no unusual problems associated with "high-velocity" bullet wounds in Vietnam. There were no reports of rifle bullet wounds causing traumatic amputation of an extremity. No one recommended removal of an amount of tissue even remotely approaching a 9-inch-diam-

eter cylinder from the wound caused by an AK-47 or any other rifle.

Other reports on rifle bullet wounds from Vietnam also gave a very different impression: "Uncomplicated perforating soft-tissue wounds were the most common bullet wounds of the extremities. They showed small entry and exit wounds and a clean soft-tissue track with little or no devitalization of tissue. Such wounds usually healed if left alone."⁹

WOUNDING MECHANISMS

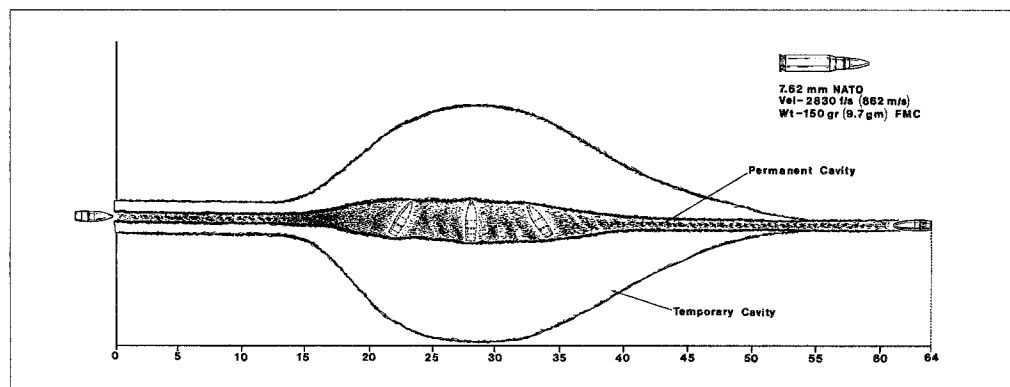
The objective measurement of a wound's dimensions, along with a clear and precise description of the tissue disruption (augmented by good-quality photographs including a measuring scale) is the only valid method of verifying the disruption caused by a given bullet. This method permits meaningful comparison of the disruptive effects caused by various bullets.¹⁰

Basic physics verifies that a projectile's potential to disrupt tissue is determined by both its mass and its velocity. Wounding potential is also determined to a great extent by a bullet's physical characteristics. Projectile construction and shape determine a bullet's tendency to deform, fragment, or change its orientation (by becoming unstable and "yawing," or turning sideways, relative to the line of flight). Such behavior in tissue greatly affects tissue disruption. For example, an expanding soft-point or hollow-point bullet causes more tissue disruption than a similar but nonexpanding one, as demonstrated by comparison of Figures 1 and 2.

Many current textbooks of surgery, however, claim that a bullet's velocity determines the severity of the wound it causes.¹¹⁻¹⁷ For wounds caused by presumed high-velocity missiles, these texts recommend extensive excision of tissue from around the projectile path, whereas if the wound was presumed to have been caused by a low-velocity projectile, little or no excision of tissue is recom-

Figure 1.

Wound profile produced by the American 7.62 NATO full metal jacket bullet. This bullet does not deform in tissue and begins to yaw after an average penetration of about 16 cm. Note that the large temporary cavity forms as a result of the blunt shape of the bullet traveling sideways.



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mended. The history of small-arms development, the physics of penetrating projectiles, findings of laboratory testing, and measurements of wounds prove the fallacy of this concept.

About 1880, the velocity of small-arms projectiles was doubled from about 1,300 feet/second (396 m/second) to more than 2,400 feet/second (731 m/second). This was the largest velocity increase in the history of small-arms development, made possible by the inventions of the jacketed bullet (in which the soft lead core was covered with a jacket of harder metal) and smokeless gunpowder. If current textbooks are correct in their assertion that a projectile's velocity alone determines its wounding capacity, such a large increase in velocity would have caused a large increase in wound severity. In fact, just the opposite effect occurred. A striking decrease in wounding effect was reported from all battlefields on which the new bullets were used.¹⁸⁻²¹ The reason is made clear when the wound profiles of the bullets involved are studied. These profiles were made by shooting into ordnance gelatin calibrated against living pig muscle²² and validated by measurements taken during human autopsies.²³

Figure 2.

Wound profile produced by the 7.62 NATO cartridge loaded with a soft-point hunting bullet. This cartridge is more commonly known as the .308 Winchester in civilian circles. This bullet expands to more than double its original diameter and loses about one third of its weight in fragments, within an inch or so of striking tissue. These fragments cause multiple perforations of the tissue surrounding the bullet path, penetrating up to 9 cm radially. The large temporary cavity then displaces this tissue, which has been weakened by multiple perforations by fragments. The synergy between fragmentation and cavitation results in detachment of pieces of muscle and increases the permanent-cavity dimensions.

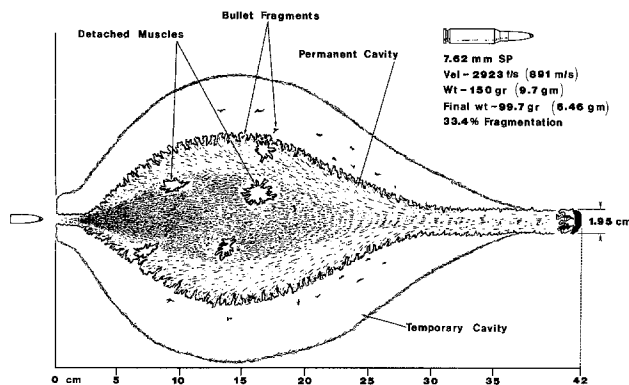


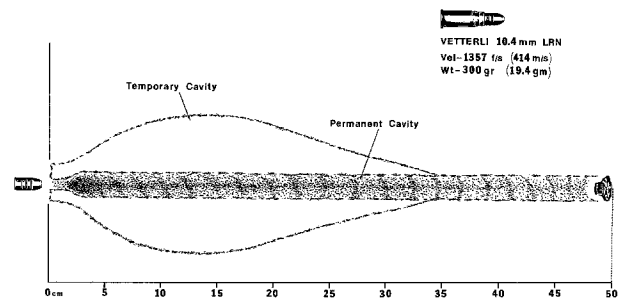
Figure 3 shows the wound profile of a typical example of the last generation of bullets made from solid lead. The velocity of such a bullet was about that of present day 22-caliber rimfire bullets, with diameters ranging from 41 to 45 caliber (10.4 to 11.4 mm). These bullets weighed from 300 to 500 grains (19.4 to 32.4 g). When these large, soft lead bullets struck flesh, they flattened, assuming a mushroom shape: This enlarged the diameter to 60 to 80 caliber (13.4 to 20.3 mm). In addition to making a larger hole, the blunted shape of the flattened bullet caused temporary cavities as large as those caused by modern M-16 rifle bullets (compare Figures 3 and 4).

Figure 5 shows the behavior of the 6.5-mm Mannlicher-Carcano bullet, typical of the first jacketed bullets. Its diameter and mass were only about half those of previous lead bullets. The jacketed bullets' much higher velocity required a decrease in bullet mass; otherwise recoil would have been excessive. The most striking characteristic of these long, round-nosed, small-caliber bullets was the tendency to travel point-forward in soft tissue until about 24 inches (61 cm) was penetrated. The jacketed bullets did not flatten or deform in human soft tissue but made small, punctate holes, disrupting little tissue (unless one struck bone, in which case it might become deformed or yaw).

The fear that these new bullets would prove insufficient to incapacitate enemy soldiers was realized by the British, in India, in 1895. They modified the bullets (at

Figure 3.

Wound profile produced by the Vetterli bullet. This bullet is typical of those used by military forces in the last half of the 19th century (the Vetterli was used by the Swiss and Italian armies from about 1870 to 1890). It flattens on striking tissue, expanding its diameter and giving it a blunt shape that allows it to produce a substantial temporary cavity despite its "low" velocity. The 44 Magnum hollow-point rifle bullet is one modern bullet that produces a wound profile similar to that of the Vetterli.



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the Dum-Dum arsenal) by grinding off some of the hard jacket at the bullet's tip. This modification caused the bullets to expand on striking flesh and to produce increased disruption. The Hague Peace Conference of 1899, however, prohibited the Dum-Dum modification for use in military conflicts.²⁴

Later military rifle bullets, with pointed noses, traveled shorter distances in the body point-forward than did the earlier round-nosed ones (compare Figures 1, 4 and 6 with Figure 5). The farther a nondeforming bullet travels

point-forward in tissue, the less tissue it disrupts.²⁵ Figure 7 shows the distance various military rifle bullets travel in tissue before they yaw.

The Russian AK-47/Chinese SKS military bullet (7.62 × 39 mm) is considerably more stable in tissue than other modern military rifle bullets. The path of an AK-47 bullet through the body is generally not long enough for yaw; most cause no greater tissue disruption than common handgun bullets.^{9,10}

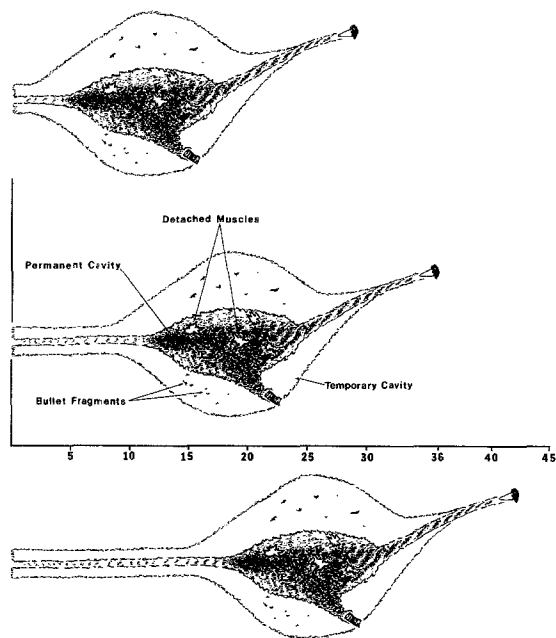
The myth that "shock waves" generated by a bullet cause tissue damage was laid to rest in 1947 when Harvey et al examined the differences between the two types of pressure waves produced by penetrating projectiles.²⁶ The first, commonly known as the "shock wave" but more properly called the sonic pressure wave, is simply the sound of the projectile striking the surface of the tissue or tissue simulant. This sound wave travels ahead of the bullet: The speed of sound in tissue is approximately 4,750 feet/second (1,450 m/second), considerably faster than the speed at which bullets penetrate tissue. In the studies by Harvey et al, these sonic waves, produced in water when a 3/16-inch (4.7-mm) steel sphere struck at 3,000 feet/second (914 m/second), produced pressures up to 60 atm but their duration was but a few microseconds. These sonic waves did not move the water perceptibly.

A second pressure wave follows the penetrating projectile. Termed "temporary cavity," it results when the penetrating projectile strikes tissue, which then accelerates radially away (like a splash) from where the projectile struck, obeying Newton's laws of motion.²⁷ The temporary cavity pressure produced by Harvey et al was about 4 atm; it pulsed a few times and lasted 4 or 5 milliseconds per pulsation.^{26,28} In these experiments the temporary cavity did move tissue, and it could be a significant wounding mechanism, depending on its size and the characteristics of the tissue it dislodged.^{26,28-31} Inelastic tissues such as liver are far more susceptible to disruption by the temporary cavity than are more flexible body tissues such as muscle, bowel wall, and lung.^{29,30-31}

The observation by Harvey et al that the sonic pressure wave does not move tissue perceptibly but that the temporary cavity does is consistent with predictions from basic physics. Compare the impulse (the capacity to change the momentum of, or move, a body) available in each of these waves by multiplying its pressure by the duration: the sonic wave might reach 60 atm but only lasts a few microseconds ($60 \times 3 = 180$); the temporary cavity might only reach 4 atm but lasts several pulsations of 4 or 5 milliseconds each, a total of about

Figure 4.

Three variations in the wound profile produced by the M-16A1 full metal jacket bullet. All the military bullet wound profiles (Figures 2-4) shown are of the average profile; in about 7 of 10 cases the distance before yaw will be within $\pm 25\%$ of that shown. This figure shows the variations in distance of penetration before yaw and the concomitant variations in wounding pattern seen with the M-16A1 military rifle bullet. The middle profile is the average one, seen in about 70% of cases; the top and bottom profiles each occur in about 15% of cases. In other, occasional cases, yaw occurs earlier or later than in those shown. Some observers in Vietnam believed the M16 was "terribly destructive," whereas others considered it less disruptive than needed. Most observers had seen few if any gunshot wounds before, and their knowledge of the circumstances surrounding the shootings was incomplete at best. Add to this the inherent variation illustrated in this figure, and it is easy to see why there was confusion.



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12,000 microseconds ($4 \times 12,000 = 48,000$). Therefore temporary cavity pressure waves produce between 200 and 300 times more capacity to move tissue than the sonic wave.

Harvey et al²⁶ explained the difficulties posed by the coexistence of the two kinds of pressure waves by separating the sonic wave from the temporary cavitation. They used two methods. First, they shot into a steel plate placed against the water surface in a water tank; the sonic wave passed through the plate and into the water, but the projectile was stopped, essentially eliminating temporary cavity—caused motion in the water. They also suspended frog hearts in water, shot spheres near them, and recorded the sequence with high-speed imaging equipment. Because the sonic wave precedes the projectile and the temporary cavity follows it, Harvey et al were able to observe that the disruption of tissue accompanied the pressure changes caused by the temporary cavity, not those of the sonic wave.

Between 1987 and 1990, five papers by Swedish researchers were published³²⁻³⁶ that purported to show evidence that Harvey et al were wrong and that sonic pressure (“shock”) waves generated by .24-inch (6-mm) steel spheres shot at 3,937 to 4,922 feet/second (1,200 to 1,500 m/second) into the legs of 20-kg pigs caused damage to various distant parts of the pigs’ nervous systems. These investigators ascribed their results to the sonic wave, but failed to consider the far more likely

possibility that tissue movement from transmitted temporary cavitation was the causative factor. High-speed cinematographic films of small pigs shot with various bullets show that the entire body of the animal can be moved by the pulsating temporary cavity caused by the projectiles used in the aforementioned studies.³²⁻³⁶

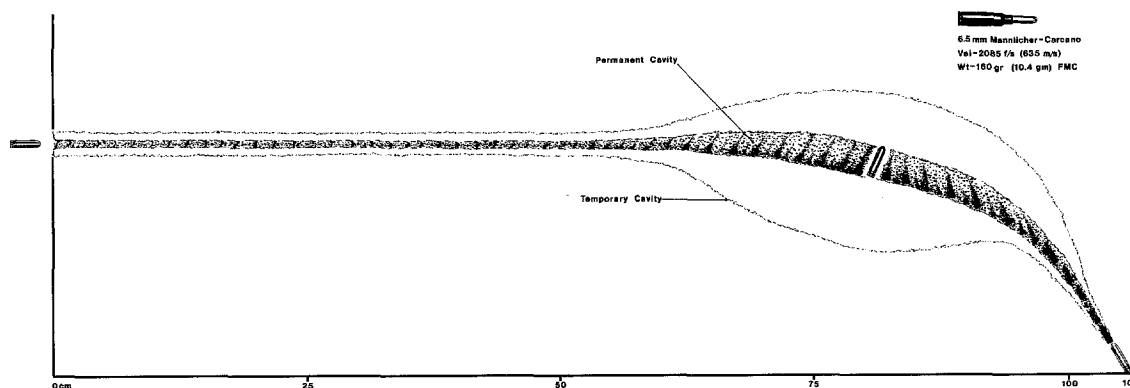
Two studies by French and American investigators provided the opportunity to search for nervous system dysfunction and other “distant effects” resulting from sonic waves or transmitted cavitation.^{31,37} No indication of nervous system dysfunction was seen, and no evidence of injury “distant” from the bullet path was found at autopsy in either study.

In March 1994 American researchers claimed to have identified shock waves as a mechanism of tissue damage in 326 cases (2% of the 16,316 gunshot wound cases they reported).³⁸ This appears to be the first report in which any investigator has claimed to have detected damage in human beings caused by the shock waves produced by bullets. These investigators apparently did not confuse shock waves with temporary cavitation; they listed cavitation as another mechanism of tissue damage. Unfortunately, this group failed to describe their criteria for determining that tissue had been injured by shock waves.

A modern researcher wishing to study the sonic pressure wave could avoid the confounding effects of cavitation by using a lithotripter. The lithotripter generates sonic pressure waves without using a projectile, therefore

Figure 5.

Wound profile produced by the 6.5 Mannlicher-Carcano full metal jacket bullet. Note that this bullet does not deform in tissue and that it penetrates an average 61 cm before beginning to yaw, accounting for its deep penetration. This is the bullet used to assassinate President John F Kennedy. Had the wound profile illustrating the penetration potential of this bullet been available at the time of the investigation into the murder it would have allayed doubts about the capacity of a single 6.5-mm bullet to have passed through the base of the president's neck, then continued through the chest of Texas Governor John Connally and then through Connally's wrist (including the distal radius) before penetrating his thigh.



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yielding no temporary cavity. Despite the fact that the sonic waves generated by the lithotripter have three times the amplitude of those produced by small-arms projectiles, and as many as 2,000 waves might be used during a single treatment session for the treatment of renal calculi, these sonic waves do not significantly harm the surrounding tissues.^{39,40}

In contrast, the damage caused in the human body by a bullet's temporary cavity can vary greatly, depending on the size of the cavity and its anatomic location. The forces of the temporary cavity follow the path of least resistance, separating tissue planes and tearing tissues where they are fixed and cannot be displaced. For instance, the cavity caused by most expanding handgun bullets is about 9 cm in diameter (Figure 8). To determine tissue movement surrounding the permanent bullet path, first subtract the 2-cm permanent bullet path. Then divide the remaining 7 cm diameter by 2 to obtain the radius, 3.5 cm (the distance in question). In a shot through the abdomen, the temporary cavity forces move a loop of small bowel only about 3.5 cm (1.4 inches). This 9-cm-diameter cavity is also likely to be absorbed in muscle or lung tissue without any damage. In the liver, however, it could cause serious damage because of the tissue's inelasticity. In the cranial cavity a 9-cm temporary cavity will most likely cause instant death as a result of the inability of brain tissue (restrained by the cranial vault) to move aside.

When—as a result of increased projectile size, increased velocity, or both—the temporary cavity is large enough to damage muscle tissue, the damage is patchy and not necessarily correlated with its distance

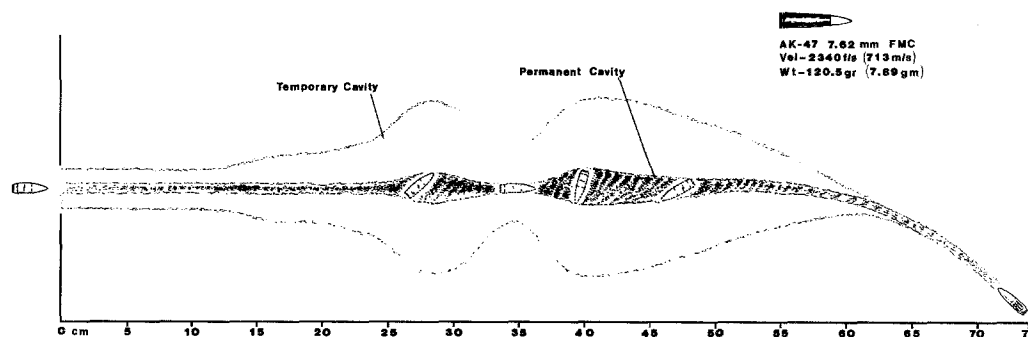
from the permanent wound path. Microscopic sections were made and studied in conjunction with the study reported in reference 31 (14-cm diameter cavities in the thighs of 90-kg pigs). These sections showed patchy tears of muscle tissue and torn small blood vessels in the muscle. The muscle damage and blood vessel damage often were not found in the same area (Fackler MJ, Breteau JPL, Unpublished data, 1988). When one recognizes that the temporary cavity simply pushes tissue aside momentarily, it becomes clear that the location and arrangement of the small blood vessels in the tissue displaced largely determine which ones will be most susceptible to being torn. The microscopic finding of patchy bleeding from torn small vessels is what one would expect knowing the mechanism causing the damage and the variation in the anatomy of the blood supply to the skeletal musculature.

Fractures from cavitation are rare in the human being: I have seen but two (both from short-range shotgun blasts) and have not seen a verified report of any in the literature. When a bone is broken by cavitation, the fracture is a simple one. A gunshot fracture with multiple bone fragments separated by several centimeters and usually mixed with fragments of the projectile is a clear sign that the bone was struck by the bullet and not damaged by temporary cavitation.

To date, no study has scientifically or objectively demonstrated any change in the human gunshot victim that cannot be explained by the well-recognized wounding mechanisms of tissue crush resulting from a direct hit by the penetrating projectile or tissue displacement from temporary cavitation.

Figure 6.

Wound profile produced by the Russian AK-47/Chinese SKS military bullet (7.62×39 mm) full metal jacket bullet. This is the most widely used "assault rifle" bullet in the world. It does not deform in tissue and travels about 26 cm before beginning to yaw. This explains the clinical finding that most wounds caused by this bullet resemble those made by much lower velocity handgun bullets.



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COMMUNICATION PROBLEMS IN WOUND BALLISTICS

Failure to adhere to the basic precepts of scientific method is the common denominator of misconceptions in wound ballistics.⁴¹ Good science is impossible without precise and clear communication, but the authors of most papers appearing in the wound-ballistics literature continue to use terms that are the antithesis of precision and clarity. These include the following.

High velocity The British draw their line between low and high velocity at 1,100 feet/second (335 m/second), which is the speed of sound in air. Various American researchers draw the line at 2,000, 2,500, or 3,000 feet/second (610, 762, and 914 m/second, respectively). In contemporary papers the terms “high velocity” and “low velocity” are often used without definition.^{32,33} Velocity should be expressed in numbers, or a numerical velocity range (eg, 900 to 1,200 feet/second).

High energy Users of this popular but ambiguous term never give it a numeric definition.³²⁻³⁶ Some wound-ballistics researchers fire 6-mm steel spheres into 20-kg pigs at about 3,200 feet/second (975 m/second) and call it a “high-energy” trauma model.⁴² Yet their “high-energy” sphere has only about 340 foot-pounds (461 joules) of kinetic energy. Many handgun bullets possess that much energy, but they are considered by most to be “low-energy” projectiles.⁴¹ The use of the imprecise “high” and “low” makes no more sense in the description of energy than it does in the description of velocity. Researchers who feel compelled to write about energy should at least describe it numerically.

Kinetic energy Tissue disruption is often discussed in terms of “local dissipation of kinetic energy.”⁴³ A valid explanation of how the penetrating projectile disrupts tissue would be more appropriate. Was the wounding

mechanism predominantly one of crushing, as would be caused by an 18-mm (71 caliber) sphere traveling in the 500- to 800-foot/second (152- to 244-m/second) range; or was it predominantly tissue tearing from being displaced and stretched beyond its elastic limits by temporary cavitation, as might be caused by a 6-mm (24 caliber) sphere traveling in the 3,000- to 3,300-foot/second (914- to 1,006-m/second) range? The amount of kinetic energy possessed by each of these projectiles might be the same, yet the pattern and type of damage they would produce are distinctly dissimilar.

“Kinetic energy” may sound erudite; however, it reveals nothing about the magnitude, type, and location of tissue disruption or the forces that cause tissue disruption—the essence of wound ballistics—and diverts attention from these critical elements. The force interactions between penetrating projectile and tissue remain hidden behind the abstract “kinetic energy” discussions.

Debridement The term “débridement” has been used by the French for several centuries: It means “to relieve tension and establish drainage by incision.”⁴⁴ During World War I, the word was adopted into English, but its meaning was confused in the transition. American writers use it sometimes as a synonym for “excision” and sometimes as a catch-all term implying that “something was done”

Figure 7.

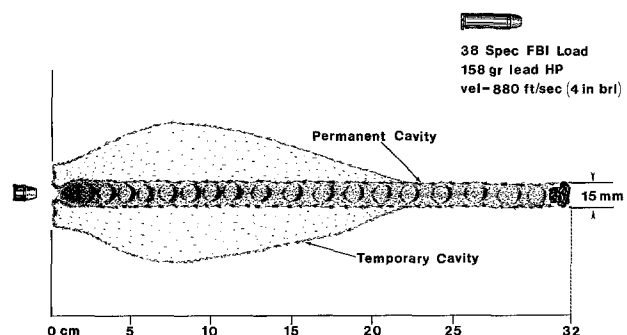
Average distances traveled point-forward in soft tissue before yawing by some common military rifle bullets.

6.5-mm Mannlicher-Carcano: 61 cm
Russian AK-47/Chinese SKS (7.62 × 39 mm): 26 cm
7.62 NATO (American version): 16 cm
M-16A1 (M-193 bullet): 12 cm
M-16A2 (M-855 bullet): 10 cm
AK-74: 8 cm.

These distances are averages: about 70% of bullets yaw within 25% of this average distance, whereas about 15% yaw at a shallower penetration depth and the other 15% at a greater depth of penetration.

Figure 8.

Wound profile produced by the 38 Special 158-grain lead hollow-point bullet. This bullet was the standard load used by the Federal Bureau of Investigation for many of the years that a revolver was used as the duty weapon. This bullet expands on striking tissue, and its diameter increases by about 50%. It produces a larger permanent cavity than non-expanding handgun bullets and a larger temporary cavity. Still, the temporary cavity it produces is not large enough to add significantly to the bullet's disruption except in tissues, such as liver, that lack elasticity.



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to a gunshot wound. Saying “the wound was debrided” communicates nothing about the specifics of what was done, yet the details of how a wound was treated are crucial to meaningful communication about wound care. “Debride” and “debridement” should be avoided in scientific discourse in favor of more precise terms such as “incision” and “excision.”³¹

PATHOPHYSIOLOGY OF GUNSHOT WOUND TREATMENT

There is little disagreement in the wound-ballistics literature about how to treat penetrating projectile wounds of the chest and abdomen or those that disrupt major blood vessels or bones. Ironically, most of the dispute and misunderstanding concerns treatment of the least lethal injuries: uncomplicated extremity wounds. Central to this dispute is how to manage the soft-tissue disruption.

Knowledge of the pathophysiology of penetrating projectile wounds is needed to choose the best treatment methods. Tissue disruption provokes increased local inflow of blood and migration of white cells and fluid through the walls of small blood vessels to combat the bacteria and to clean up devitalized tissue.^{45,46} Local swelling, which in some cases can be counterproductive and even pose a threat to life and limb (eg, a compartment syndrome) may result. Increase in compartment pressure can be prevented by wide opening of the wound path and excision of all devitalized tissue. It can also be prevented with the much simpler and less costly (in terms of surgical resources and patient complications) procedure fasciotomy, which is the closest thing in English to the original French meaning of “debridement.” Tissue swelling might not pose a problem where (1) tissue disruption is minimal, or (2) even in the face of considerable tissue disruption if cavitation caused by the bullet splits open the skin, muscle, and fascia, thereby providing excellent decompression and drainage.³¹

If the tissue damage along the bullet path is so minimal that the body defense mechanisms can absorb it, as is the case with wounds from most handgun bullets (and military rifle bullets in the portion of their path before they have yawed), most of these wounds heal without intervention.

The trauma caused by penetrating projectiles stimulates new capillaries to grow into the disrupted area.^{45,46} This increasing blood supply takes a few days to provide increased resistance to bacteria and is the reason behind the most basic tenet of surgical care of gunshot wounds:

leaving the wound open after the initial surgery and closing it after 4 to 7 days. Wartime experience has shown that immediate closure of these wounds results in a high infection rate, whereas leaving them open until the local blood supply has been augmented by ingrowth of new capillaries results in far better healing.³¹ All gunshot wounds are contaminated with bacteria. On occasion one still hears the myth that bullets reach such a high temperature in the gun barrel that they are sterilized by being fired. This was proved false by LaGarde in 1892⁴⁷, whose findings were more recently verified by Thoresby and Darlow.⁴⁸

The bacteria brought in by the bullet multiply in proportion to the amount of tissue that has been devitalized or severely damaged. When too much devitalized tissue is present for the body to absorb, the bacterial load is too great, or both, the body tries to wall off the bacteria-laden devitalized tissue by laying down a fibrin barrier.^{45,46} If the wound is open, this walled-off necrotic mass is simply expelled after about 10 days.³¹ If access to the outside is not available for the necrotic mass to be expelled, it will become an abscess. The treatment for an abscess is simple incision and dependent drainage. If incision and drainage is not performed, sufficient pressure may build up in the abscess for it to spread by breaking through its fibrin walls; erosion into blood vessels and invasive bacteremia may result. The body's defensive fibrin barriers can also be dissolved by the enzyme fibrinolysin, formed by the group A β -hemolytic streptococcus bacteria. This bacteria's capacity to spread by enzymatic action is why throughout history it has been the significant killer of the battlefield wounded.^{49,50} Since World War II, however, β -hemolytic streptococcus has nearly disappeared from battlefields because antibiotics have been used to treat virtually all wounded by projectiles. Fortunately, the streptococcus has remained very sensitive to penicillin spectrum antibiotics. An adequate blood level of a penicillin spectrum antibiotic will prevent life-threatening invasive bacteremia caused by a group A β -hemolytic streptococcus, and penicillin remains effective against the clostridial species of bacteria that cause gas gangrene.⁵¹⁻⁵³

Ideally, all dead and injured tissue surrounding the bullet path should be excised within a few hours of injury. This excision would decrease the work of the body's defenses and allow the ingrowth of new capillaries to progress unimpeded so that after 4 to 7 days the wound may be closed and uncomplicated healing expected. It is seldom possible, however, for even the most experienced surgeon to be able to identify with certainty the line of demarcation between tissue that will survive and that which will not.

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The “four Cs” (color, consistency, contractility, and circulation) have been taught to help surgeons differentiate viable from nonviable muscle. Those who support this method^{54, 55}, however, fail to advise whether abnormality in only one of these Cs indicates nonviability or whether two, three, or all four criteria must be fulfilled. During the Korean conflict, an attempt was made to measure the accuracy with which surgeons could evaluate muscle viability on the basis of the 4 Cs.⁵⁴ Biopsy specimens taken by surgeons were graded for muscle disruption by a pathologist. A “statistically significant” correlation was found for all but color. Their data, however, were not convincing: Although contractility deficits were found in all 22 of the severely disrupted muscle biopsy specimens, they were also found in 16 of the 18 judged to have been minimally disrupted. “Consistency” had the best correlation: It was judged normal in only 1 of the 22 severely disrupted specimens but was also judged normal in only 8 of the 18 minimally disrupted ones. The samples were taken an average of 6 hours after injury. Applicability to patients seen early after injury is questionable. Blood flow to tissues surrounding bullet paths can change markedly in the first few hours after wounding.³¹ Delineation of where the body will draw the line on nonviable tissue can be compounded by severe hemodynamic shock and massive injury, which can compromise body defenses.

A reasonable way of dealing with this dilemma is to remove tissue that has been partially detached or severely disrupted and then examine the open wound after 2 days, by which time it will be obvious if more tissue must be excised. This method should be suitable for most civilian trauma centers.

In the military setting, however, the goal of getting the wound to heal rapidly has led many to handle the dilemma with a more radical excision of tissue. In an attempt to remove all potentially nonviable tissue, military surgeons often use an en bloc dissection of all dead, injured, and questionable tissue along with a margin of normal tissue—a procedure akin to excision of a malignancy. The danger of carrying this approach to extremes is easy to recognize.⁴ Proponents of the “when in doubt, cut it out” school often preach that their method is necessary to avoid death resulting from invasive bacteremia or gas gangrene. This is untrue; antibiotics and the far simpler surgical incision to relieve pressure and establish dependent drainage will do that.^{31,56}

The great majority of civilian gunshot wounds are caused by handgun bullets. These bullets usually cause punctate extremity wounds that disrupt so little tissue that the body’s defenses handle it well without the need for surgery. Military surplus weapons and ammunition are commonly available⁵⁷, and information given to the treat-

ing physician by those wounded and their confreres about weapon and bullet type and the circumstances surrounding a shooting are notoriously inaccurate. Therefore perforating extremity wounds from military rifle bullets have undoubtedly been interpreted as handgun wounds in many cases and treated as such, with good results. The damage caused by the military rifle bullet before it yaws (Figures 1, 4-6) cannot be differentiated from that caused by a handgun bullet even by the most expert.^{25,41,58,59}

It is possible for a bullet wound to be punctate at its entrance and exit, and yet have caused serious muscle disruption deep in the central part of the extremity. There should be no problem, however, in separating these wounds (which might well need to be opened wide) from those with minimal disruption. Any significant buried tissue disruption in the human extremity should be easily diagnosed by physical examination and roentgenographic studies.

Modern wound ballistics is a paradox. Its fundamentals are strongly supported by the laws of physics, well illustrated, and clarified by current bullet-testing techniques and verified by centuries of observations made on battlefields. Yet its literature remains a minefield of misconceptions. Objective data explaining the basis of wound ballistics aid the physician in understanding injury potential. Wounds result when penetrating projectiles crush tissue, displace it, or both. Projectile mass, velocity, shape, and construction, as well as the characteristics and anatomic constraints of the tissue penetrated, determine the amount, type, and location of tissue disruption. No matter how expert one might be in understanding wound ballistics, understanding the medical consequences of bullet wounds is often challenging. Unknown and unexpected variables, such as contact wounds (where powder gases can add greatly to the tissue disruption) and a bullet passing through an intermediate target before impact, can change the morphology of a wound from a given weapon. The basic rule for every health care provider to remember in caring for gunshot victims is to evaluate objectively the location, extent, and type of tissue disruption and base treatment on these findings. Dr Douglas Lindsey puts it best in his advice: “Treat the wound and not the weapon.”⁷

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EXHIBIT 38

FIREARMS CHIMERA: THE COUNTER PRODUCTIVE CAMPAIGN TO BAN THE AR-15 RIFLE

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INTRODUCTION

I have always been a collector. During my childhood, I collected comic books, butterflies, coins, and stamps, with a few tentative forays into other areas as well. These interests faded over the course of military service and the other endeavors of adulthood, but my collecting impulse was merely dormant, not extinct, and has long since revived. Among its chief

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objects now are old, arcane, or noteworthy books. Having settled into the practice of law after military retirement, a few obscure old law books have naturally found their way onto my shelves.

One such book is *The Revised Statutes of Michigan*, 1838. Among the enactments of the state's early legislative sessions was one providing that "[p]ersons going about armed with dirk, &c., [sic] may be required to find sureties of the peace,"¹ and that "[i]f any person shall go armed with a dirk, dagger, sword, pistol, or other offensive and dangerous weapon, without reasonable cause to fear an assault or other injury, or violence to his person, or to his family or property, he may, on complaint of any person having reasonable cause to fear an injury, or breach of the peace, be required to find sureties for keeping the peace, for a term not exceeding six months, with the right of appealing."² Another of my old volumes, the 1849 *Code of Virginia*, contains a similar provision.³ These could be considered early versions of today's *red flag laws*—statutes enacted to facilitate the pre-emptive abridgment of a particular person's right to keep and bear arms upon the complaint of another private citizen. Like those today, these old laws required, expressly or implicitly, a reasonable basis to fear that the person sought to be restrained might do harm, and that said person be allowed to contest the restraint upon their right to own or bear arms.⁴ Somewhat more restrictive was the 1852 *Code of Alabama*, which provided:

Any one who carries concealed about his person a pistol, or any other description of fire arms, not being threatened with, or having good reason to apprehend an attack, or travelling, or setting out on a journey, must, on conviction, be fined not less than fifty nor more than three hundred dollars.⁵

Yet, even Alabama's more restrictive code permitted unrestricted open carry and allowed concealed carry when travelling or when reasonably in fear of attack.⁶ Thus, there can be no doubt that at the time they enacted these laws, the citizens of these states took it as given that the right to keep and bear arms was a private right individually vested in every peaceable citizen and that the view taken by some of their grandchildren (that the right

1. THE REVISED STATUTES OF THE STATE OF MICHIGAN 707 (E. B. Harrington & E. J. Roberts eds., Detroit, John S. Bagg, Printer to the State, 1838).

2. *Id.* at 657–58.

3. THE CODE OF VIRGINIA 756 (Richmond, William F. Ritchie, Public Printer, 1849).

4. *Id.*; THE REVISED STATUTES OF THE STATE OF MICHIGAN, *supra* note 1.

5. THE CODE OF ALABAMA § 3274 (John J. Ormond et al eds., Montgomery, Brittain and De Wolf, State Printers, 1852).

6. *Id.* § 3274–75.

to keep and bear arms is a collective right only, vested in such militia as the legislature might deign to organize, with private ownership of arms for other purposes allowed at sufferance only) would have been heresy. This is confirmed by the states' constitutional provisions in force when they enacted the laws mentioned above. The Constitution of Alabama provided that "[e]very citizen has the right to bear arms in defence [sic] of himself and the State."⁷ Michigan's Constitution contained a similar provision.⁸ The Virginia Bill of Rights, adopted June 12th, 1776, and incorporated by reference into the Virginia Constitution in force at the time of the above-cited enactments, provided "[t]hat a well regulated militia, composed of the body of the people, trained to arms, is the proper, natural, and safe defence [sic] of a free state."⁹ As Michigan Chief Justice Thomas Cooley explained:

[I]f the right [to keep and bear arms] were limited to those enrolled [in the militia], the purpose of this guaranty might be defeated altogether by the action or neglect to act of the government it was meant to hold in check. The meaning of the provision undoubtedly is, that the people, from whom the militia must be taken, shall have the right to keep and bear arms; and they need no permission or regulation of law for the purpose. But this enables the government to have a well-regulated militia; for to bear arms implies something more than the mere keeping; it implies the learning to handle and use them in a way that makes those who keep them ready for their efficient use; in other words, it implies the right to meet for voluntary discipline in arms, observing in doing so the laws of public order.¹⁰

Yet these hardy and independent citizens, jealous of their liberties, saw no inconsistency between an individual right to keep and bear arms and the imposition of a limited abridgment of that right in specific cases where a person posed a credible threat of a breach of the peace.¹¹

The revival of such laws is one proposal put forward to cope with the outrageous mass public shootings that beset us today. On its face, there would seem to be merit to the idea: it emerges in the aftermath of many such shootings where family, friends, or the authorities had good cause for

7. ALA. CONST. of 1819, art. I, § 23.

8. MICH. CONST. of 1835, art. I, § 13.

9. VA. CONST., art. I, § 13; VA. CONST. of 1830, art. I.

10. THOMAS M. COOLEY, *THE GENERAL PRINCIPLES OF CONSTITUTIONAL LAW IN THE UNITED STATES OF AMERICA* 271 (Boston, Little, Brown, and Co. 1880).

11. *See* THE REVISED STATUTES OF THE STATE OF MICHIGAN, *supra* note 1, at 657–58; *see also* COOLEY, *supra* note 10, at 271.

concern about the shooter beforehand, but failed to act.¹² A carefully drafted statute, with an appropriate standard of proof, and fair, reasonable, and prompt due process protections for the person purported to be a threat, might have prevented some attacks. However, many American gun owners vigorously resist such proposals, attracting the criticism that they oppose any firearms restrictions at all, including gun control advocates' own supposedly "common sense gun safety" proposals.

Gun control advocates take this opposition as proof of pro-Second Amendment advocates being in the thrall of the "gun lobby." This misses the mark, however, for as David Hardy has shown, gun owners have ample reason to be skeptical of gun control advocates' proposals.¹³ This is unfortunate, for the natural impulse of gun rights advocates ought to be to support such laws: As a group, gun owners tend to be conservative, to value law and order, to favor tough-on-crime policies, to be strong supporters of law enforcement, and at least one researcher has found that they also tend to be relatively non-violent.¹⁴ This paper examines one source of this inconsistency: the argument over whether to ban the AR-15 rifle and similar firearms and the impact of that proposal on the overall gun violence debate.

I. THE FUNCTION OF THE RIGHT TO KEEP AND BEAR ARMS IN AMERICAN SOCIETY

The American tradition of arms and the private right to keep and bear arms, which is one of its political manifestations, is complex and multifaceted. It encompasses a wide range of functions. These include practical personal applications, such as subsistence, sport, and self-defense; collective applications such as defense of the community and resistance to tyranny; and potent political, cultural, historical, and mythological functions. In the American political tradition, private ownership of arms finds its highest and most fundamental function in serving as a badge of sovereignty. According to Max Weber, the "state is a human community that (successfully) claims the monopoly of the legitimate use of physical force within a given territory."¹⁵ In many political systems, the embodiment

12. Cf. Will Garbe et al., *Dayton Shooting: Oregon District gunman left decade of red flags*, Dayton Daily News (Aug. 9, 2019) [<https://perma.cc/9FZZ-WRPD>] (stating family and friends of a mass shooter had previous red flag's regarding shooter's behavior and mental state).

13. David A. Hardy, *Gun Owners, Gun Legislation, and Compromise*, 31 T.M. COOLEY L. REV. 33, 35 (2014).

14. See John R. Lott & David B. Mustard, *Crime, Deterrence, and Right-to-Carry Concealed Handguns*, 26 J. LEGAL STUD. 1, 2–3 (1997).

15. Max Weber, *Lecture: Politics as a Vocation*, 1 (1918) (transcript available at <http://anthropos-lab.net/wp/wp-content/uploads/2011/12/Weber-Politics-as-a-Vocation.pdf> [<https://perma.cc/5VAF-9Z5T>]) (emphasis omitted).

of the state and the locus of sovereignty is a political party, a monarch or autocrat, or a political institution, such as parliament or the army.¹⁶ However, under the American political creed as expressed in its founding documents, the state is the mere agent of the People, governing at their sufferance, with the People themselves remaining the locus of sovereignty.¹⁷ As the collective sovereign, they retain for themselves a private right to maintain the means of physical force, separate and apart from that entrusted to the state, as manifested in the Constitutional right to keep and bear arms.¹⁸

This is evident in the attitudes toward the bearing of arms by slaves during the antebellum period and by the Freedmen following the Civil War.¹⁹ Among the most regrettable relics of the Antebellum period is Chief Justice Roger B. Taney's infamous opinion in *Dred Scott v. Sandford*, arguably the most odious holding ever emitted by the courts of any Common Law country. One of *Dred Scott's* principal holdings was that neither Congress nor the states had the power to naturalize African slaves or their descendants.²⁰ Among the litany of Taney's objections to such naturalization was that conferring citizenship upon slaves or their descendants would give them the right, among other things, "to keep and

16. See *id.* at 1–2 (charismatic or personal rule), and 8 (parliamentary supremacy). For an example of the Army as the locus of sovereignty, consider the Revolutionary Army of Mexico from 1910 to 1940; see Edwin Lieuwen, *Mexican Militarism: The Political Rise and Fall of the Revolutionary Army* (The University of New Mexico Press, 1968), page xii.

17. The U.S. Declaration of Independence provides, "That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed, — That whenever any Form of Government becomes destructive of these ends, it is the Right of the People to alter or to abolish it, and to institute new Government, laying its foundation on such principles and organizing its powers in such form, as to them shall seem most likely to effect [sic] their Safety and Happiness." The U.S. Constitution provides, in the Preamble, that "**We the People** of the United States, in Order to form a more perfect Union, establish justice, insure domestic Tranquility, provide for the common defence [sic], promote the general Welfare, and secure the Blessings of Liberty to ourselves and our Posterity, **do ordain and establish this Constitution for the United States of America**" (emphasis added). See also ALA. CONST. of 1819, *supra* note 7, at art. I, §2, "All political power is inherent in the people, and all free governments are founded on their authority"; MICH. CONST. of 1835, *supra* note 8, at art. 1, §1, "[a]ll political power is inherent in the people;" THE CODE OF VIRGINIA, *supra* note 3, at 32, "all power is vested in, and consequently derived from, the people; that Magistrates are their trustees and servants, and at all times amenable to them."

18. See U.S. CONST. amend. II.

19. *Scott v. Sandford*, 60 U.S. 393, 417 (1857), *superseded by constitutional amendment*, U.S. CONST. amend. XIV; David B. Kopel, THE SECOND AMENDMENT IN THE NINETEENTH CENTURY, 1998 BYU L. REV. 1359, 1452–54 (1998).

20. *Scott*, 60 U.S. at 420.

carry arms wherever they went.”²¹ By contrast, after the Civil War, the Republican-controlled Congress adopted the opposite policy during Reconstruction.²² Congress enacted measures, such as the Freedmen’s Bureau Act of 1866, which provided that “the right to ... have full and equal benefit of all laws and proceedings concerning personal liberty, [and] personal security ... including the Constitutional right to bear arms, shall be secured to and enjoyed by all the citizens of such State or district without respect to race or color or previous condition of slavery.”²³ Furthermore, “[t]he framers intended and opponents recognized the Fourteenth Amendment to guarantee the right to keep and bear arms as a right and attribute of citizenship that no State government could infringe.”²⁴ They also intended that the Fourteenth Amendment would extend these rights to the Freedmen. As Stephen Halbrook argued:

The arms that the Fourteenth Amendment’s framers believed to be constitutionally protected included the latest firearms of all kinds, from military muskets (which were fitted with bayonets) and repeating rifles to shotguns, pistols, and revolvers. The right of the people to keep arms meant the right of an individual to possess arms in the home and elsewhere; the right to bear arms meant to carry arms on one’s person. The right to have arms implied the right to use them for protection of one’s life, family, and home against criminals and terrorist groups of all kinds, whether attacking Klansmen or lawless law enforcement. Far from being restricted to official militia activity, the right to keep and bear arms could be exercised by persons against the state’s official militia when it plundered and killed the innocent.²⁵

While the importance of each has waxed and waned over time according to the conditions prevailing in the country at any given moment, each facet of the private right to keep and bear arms has shaped American

21. *Id.* at 417.

22. *See Congress Profiles: 39th Congress (1865–1867)*, HISTORY, ART & ARCHIVES: UNITED STATES HOUSE OF REPRESENTATIVES, <https://history.house.gov/Congressional-Overview/Profiles/39th/> [<https://perma.cc/L6HR-57YW>]; STEPHEN P. HALBROOK, FREEDMAN, THE FOURTEENTH AMENDMENT, AND THE RIGHT TO BEAR ARMS, 1866-1876, at 40–41 (1998).

23. HALBROOK, *supra* note 22, at 40–41 (emphasis omitted).

24. *Id.* at 42 (emphasis added).

25. *Id.* at 43.

culture and history in its turn and continues to do so to a greater or lesser degree today.²⁶

The use of ranging weapons for subsistence hunting dates back tens or even hundreds of thousands of years.²⁷ Nonetheless, it seems unlikely

26. These functions do not merely fade in importance over time; they sometimes wax more important. See, for example, Walter G. Libber, *Every Citizen A Rifleman*, NATIONAL SERVICE WITH THE INTERNATIONAL MILITARY DIGEST, Apr. 1919, at 207-09 (deploring the fact that while “[t]he American is traditionally a rifleman,” with the growth of our population, “centered in the towns,” “our skill and confidence in the use of firearms gradually decreased,” even to the point that it became “a deplorable fact that shortly before signing the armistice [ending WWI] during the operations of the Argonne American soldiers were sent into the front lines who had never fired a rifle,” and that “it is a well-known fact that our urban population is cut off from any opportunity of learning the use of the rifle...”); compare this to the situation one hundred years later, where firearms use has dramatically rebounded to the point that “[m]ore people participate in target shooting than play tennis, soccer or baseball,” with shooting sports generating over \$16 billion in retail sales annually (National Sports Shooting Foundation, *Target Shooting in America, A Force for Conservation*, 2019), and National Public Radio reporting that, notwithstanding high profile incidents of gun violence, shooting ranges in the United States are booming, with the National Sports Shooting Foundation listing “hundreds and hundreds of shooting ranges in the United States, including more than 1,800 that have special programs for women and young people. Linton Weeks, *Are Shooting Ranges The New Bowling Alleys?* NPR, <https://www.npr.org/2013/01/31/170391799/are-shooting-ranges-the-new-bowling-alleys>, retrieved Sept. 5th, 2020. Consider also the changing face of competition shooting in the United States, which was driven largely by state militia organizations in the 19th Century (see generally James B. Tefethen and James E. Serven, *Americans and Their Guns*, Stackpole Books, 1967), as compared with the contemporary sports shooting scene, in which competition shooting has expanded considerably to include large numbers of civilian shooters of both sexes (see *Frontsight*, the magazine of the USPSA, cited elsewhere in this work), also discussed at Chapman, *Features and Lawful Common Uses of Semi-Automatic Rifles*, cited elsewhere in this paper. Furthermore, even when the role of a particular shooting application does fade in prominence, it rarely if ever fades to the point of irrelevance. Consider, for example, hunting: In *Sport Hunting and Conservation, 1880 – 1920*, ENVIRONMENTAL REVIEW: ER Vol. 12, No. 1 (Spring, 1988), at 51-60, Thomas R. Dunlap discusses the transition from “pot hunting to sport hunting” (page 53), and the subsequent decline in hunting popularity in recent generations; but notwithstanding said change, hunting remains a major component of American culture. Consider that there were nearly 11.5 million hunters in the United States as of 2016, a number exceeding the populations of 43 states, and that these hunters spent \$27.1 billion pursuing their sport that year (National Sports Shooting Foundation, *Hunting in America: An Economic Force for Conservation*, 2018). For discussion of how the AR-15 has displaced earlier firearms platforms in pursuit of these activities, see Chapman, *Features and Lawful Common Uses of Semi-Automatic Rifles*; the ATF’s Ronald Turk; and AR15Hunter.com, all cited elsewhere in this paper.

that many Western Europeans were still dependent upon subsistence hunting by the time firearms technology emerged and took hold with sedentism, herding, and agriculture having emerged in the Fertile Crescent 12,000 years ago and spread across Europe from 8,800 to 5,500 years ago, millennia before the invention of firearms.²⁸

However, the very different conditions prevalent in North America made the earliest English colonists here heavily dependent upon firearms for their survival, with the Native American tribes becoming dependent upon the same technology themselves in due course.²⁹ Thus, the Jäger rifles, made by German gunsmiths as the accoutrement of European sportsmen, became the Pennsylvania or Kentucky long rifle—a tool of practical necessity for daily life—when those gunsmiths migrated to the New World.³⁰ Economic and technical developments have since rendered subsistence hunting obsolete.³¹ As hunting author, Norman Strung, once noted: “Since man first learned to use weapons, he has hunted to obtain food. [But] [e]xcept in the remotest corners of the world, hunting is no longer necessary for survival.”³²

Privately-owned firearms were decisively important to the collective defense of the community in North America in a way never contemplated in Europe.³³ In North America, “defense of country and laws [would] be secured through the Militia—civilians primarily, soldiers on occasion” who “when called for service these men were expected to appear bearing arms supplied by themselves and of the kind in common use at the time.”³⁴ However, the growth of the Army National Guard has largely displaced the individual, armed citizen in the role of collective defense of the local community.³⁵

27. Corey A. O’Driscoll & Jessica C. Thompson, *The Origins and Early Elaboration of Projectile Technology*, *EVOLUTIONARY ANTHROPOLOGY*, Jan./Feb. 2018 at 30, 31, 35, 41.

28. See Solange Rigaud, *Ornaments Reveal Resistance of North European Cultures to the Spread of Farming*, *Plos One* (Apr. 8th, 2015), <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0121166> (last visited Sept. 5th, 2020).

29. DAVID HARSANYI, *FIRST FREEDOM: A RIDE THROUGH AMERICA’S ENDURING HISTORY WITH THE GUN* 24–25, 49 (1st Threshold ed. Hardcover Oct. 2018).

30. *Cf. id.* at 26–30 (discussing the evolution of the Kentucky rifle).

31. See NORMAN STRUNG, *DEER HUNTING: TACTICS AND GUNS FOR HUNTING ALL NORTH AMERICAN DEER* 7 (J.B. Lippincott Co. 1973).

32. *Id.*

33. See HARSANYI, *supra* note 29, at 20.

34. *United States v. Miller*, 307 U.S. 174, 179 (1939).

35. See generally Christopher R. Brown, *Been There, Doing That in a Title 32 Status: The National Guard Now Authorized to Perform Its 400-Year Old Domestic Mission in Title 32 Status*, *ARMY LAW.*, May 2008, at 23, 23, 26, 35 (discussing how the National Guard’s role has changed).

Although the foregoing applications of privately owned arms are no longer a practical necessity for daily survival, they are still valuable and important. As Strung has observed: “[A] heritage stretching for eons can’t be denied by a paltry few centuries of ‘civilization.’”³⁶ Additionally, the nearly miraculous growth and development of the United States since achieving independence does not rule out the revival of the day to day importance of these shooting applications in the event of future emergency.³⁷ Nonetheless, the applications of privately-owned firearms that are of greatest practical importance to Americans today are sporting purposes and, most importantly, personal self-defense against violent attack.³⁸

II. THE MOVING GOAL POSTS OF THE GUN CONTROL MOVEMENT

The stated aim of red flag laws is to get guns out of the hands of the imminently violent, while leaving them in the hands of peaceable citizens. Notwithstanding this, many gun owners vigorously oppose red flag laws. Sadly, this opposition is neither unreasonable nor, regrettably, unjustified. For gun control advocates have given American gun owners ample reason to view all of their proposals, no matter how benign they may seem, as a mere Trojan horse, offered to gain a foothold from which to enact ever more draconian gun control measures.³⁹ From the perspective of reducing gun violence, today’s American-gun-control lobby agenda is counterproductive in the extreme, being almost perfectly calibrated to generate the implacable opposition of American gun owners to any proposals that might be put forward—a constituency at least some of whose support will be essential to pass any reform.⁴⁰

36. STRUNG, *supra* note 31, at 7.

37. Having served in the relief effort in Homestead, Florida following devastation of Hurricane Andrew, and having observed the dystopian societal collapse of Somalia triggered by that country’s suicidal civil war in the early 1990s via my service there during Operation Restore Hope in 1992 and 1993, I can attest from personal observation to the fragility of our civilized existence. For a visual depiction of the devastation caused by Hurricane Andrew, see *THE BIG ONE: HURRICANE ANDREW* (Andrews & McNeel, 1992). For a discussion of the savage brutality of the Somali civil war and the dystopian nightmare that followed it, see LIDWIEN KAPTEIJNS, *CLAN CLEANSING: THE RUINOUS LEGACY OF 1991* (University of Pennsylvania Press, 2013); for accounts of the U.S. military involvement in Somalia, see Martin Stanton, *Somalia on \$5.00 a Day: A Soldier’s Story* (Presidio, 2001); and LAWRENCE E. CASPER, *FALCON BRIGADE: COMBAT AND COMMAND IN SOMALIA AND HAITI* (Lynne Rienner, 2001).

38. GARY A. KLECK, *POINT BLANK: GUNS AND VIOLENCE IN AMERICA* 41–42 (Aldine De Gruyter 1991).

39. Hardy, *supra* note 13, at 37–39, 42, 46.

40. *Id.* at 39, 42, 45–46.

No single gun policy proposal has done more to discredit gun control advocates in the eyes of American gun owners than the obsession with banning the most popular rifle in the United States, the AR-15.⁴¹ In their quest to ban the AR-15, gun control advocates have discredited themselves by candidly admitting that their true aim is not so much the elimination of that particular rifle, but the opening up of an aperture through which further, more extreme restrictions might be pursued.⁴² As early as 1989, the Violence Policy Center noted that “assault weapons are quickly becoming the leading topic of America’s gun control debate and will most likely remain the leading gun control issue for the near future. Such a shift will not only damage America’s gun lobby, but strengthen the handgun restriction lobby.”⁴³ The *Washington Post* admitted in 1994 that “[t]he [crime] bill also includes a ban on assault weapons . . . but no one should have any illusions about what was accomplished. Assault weapons play a part in only a small percentage of crime. The provision is mainly symbolic; *its virtue will be if it turns out to be, as hoped, a stepping stone to broader gun control*.”⁴⁴ As criminologist Gary Kleck has noted,

41. Examples of this single minded focus on AR-15s and similar rifles in recent years abound: Popular horror writer Stephen King, an outspoken advocate for gun control, calls for the banning of “the sale of assault weapons such as the Bushmaster and the AR-15,” while assuring us that he has no designs on our other guns: “Guys, gals, now hear this: no one wants to take away your hunting rifles. No one wants to take away your shotguns. No one wants to take away your revolvers, and no one wants to take away your automatic pistols, as long as said pistols hold no more than 10 rounds” (also note how he seems not recognize that the “Bushmaster” is not a separate category of firearm, but merely one brand under which the AR-15 platform is sold) See Stephen King, *Stephen King: Why the US Must Introduce Limited Gun Controls*, THE GUARDIAN (Feb. 1, 2013, 8:27 AM), <https://www.theguardian.com/books/2013/feb/01/stephen-king-pulled-book-gun-controls> [<https://perma.cc/E5ZP-9QUG>]; When asked about gun owners who feel that “a Biden Administration means they’re going to come for my guns,” former Vice President, Joe Biden, replied, “Bingo, you’re right if you have an assault weapon.” David Harsanyi, *Of Course Joe Biden Wants to Take Your Guns Away*, THE CORNER -- NAT’L REV. Online, Mar. 10th, 2020, <https://www.nationalreview.com/corner/joe-biden-second-amendment-of-course-he-wants-to-take-your-guns-away/> retrieved September 5th, 2020); and presidential candidate Beto O’Rourke declared that “hell, yes, we are going to take your AR-15, your AK-47” (Todd J. Gillman, *Beto ‘Hell yes’ O’Rourke’s endorsement has Joe Biden fending off allegation that he’s a gun-grabber*, The Dallas Morning News, March 10th, 2020, <https://www.dallasnews.com/news/politics/2020/03/10/beto-hell-yes-orourkes-endorsement-has-joe-biden-fending-off-allegation-that-hes-a-gun-grabber/> (last visited Sept. 5th, 2020).

42. Editorial, *Hyping the Crime Bill*, WASH. POST., Sept. 15, 1994, at A16.

43. *Assault Weapons and Accessories in America*, THE VIOLENCE POL’Y CTR. (1988), <https://www.vpc.org/studies/awaconc.htm> [<https://perma.cc/8Q9A-FHWQ>] (emphasis added).

44. *Hyping the Crime Bill*, *supra* note 42.

Leaders of procontrol [sic] advocacy groups such as Handgun Control and the Coalition to Stop Gun Violence (previously the National Coalition to Ban Handguns) used to assure audiences that they were interested only in regulating handguns, so hunters and sport shooters who used rifles and shotguns had nothing to fear from them.... Yet, once “assault rifles” became a highly publicized issue, leaders of these groups immediately pushed for strict controls on semi-automatic rifles ... This kind of policy shift undercuts their credibility regarding their ultimate intentions, and feeds the worst paranoia of anticontrol extremists. In Don Kates’ words, this sort of “extremism poisons the well,” making it all the harder to get people to seriously consider more reasonable alternatives.⁴⁵

As Kleck further notes,

[i]t would be unfair to generalize from such cases to all supporters of moderate controls [as] [u]ndoubtedly, many of those who insist they are not interested in further controls are sincere[;] [u]nfortunately, it is impossible for gun owners to know for sure which gun control supporters are sincere, how numerous they are, whether they will continue in the future to adhere to their commitment to limited controls, and whether they will dominate the gun control movement in the future. There are uncomfortable historical parallels between the gun control movement and the Temperance movement. The latter movement was originally directed toward regulating alcohol and encouraging, as its name suggested, moderation in drinking and reduction in alcoholism. Yet it eventually evolved into the national Prohibition movement, which completely banned the production and sale of alcohol and thereby criminalized millions of Americans (citation omitted).⁴⁶

III. FIREARMS EVOLUTION AND THE EMERGENCE OF A UNIQUELY MILITARY FIREARMS CAPABILITY

In pursuit of banning the AR-15 “as a stepping stone to broader gun control,” gun control advocates have bet heavily on their view that “[t]he weapons’ menacing looks, coupled with the public’s confusion over fully automatic machine guns versus semi-automatic assault weapons—anything

45. KLECK, *supra* note 38, at 10.

46. *Id.* at 10–11.

that looks like a machine gun is assumed to be a machine gun—can only increase the chance of public support for restrictions on these weapons.”⁴⁷ However, they have not sat by and complacently waited for the AR-15’s martial appearance to carry the day for them. They have embarked upon a vigorous, unflagging disinformation campaign to frighten the public into demanding that the AR-15 be banned. One rhetorical device frequently deployed is to characterize the AR-15 as a “weapon of war.” Notwithstanding the AR-15’s outward appearance, this characterization is groundless, resting in part upon the common misconception that “[m]ost firearms, no matter what their current uses, derive directly or indirectly from firearms originally designed for the military.”⁴⁸ However, not only have developments in civilian and military firearms technology been interrelated throughout history, but important technological advancements have often been accepted in civilian firearms long before being accepted for military applications.⁴⁹ This tendency toward military skepticism of new developments in firearms technology, even manifested itself to a small degree with respect to Armalite’s ground breaking design that would become the AR-15 and later the M16, is evident from the Army’s 1966 marksmanship field manual, which sniffed that “the much-argued-for superiority of lightweight alloys, plastics, and glass compounds must be balanced against the yet-to-be-confirmed field observations of their wearing qualities and stress resistance.”⁵⁰

One noteworthy example of the lag in military acceptance of firearms technology developed for civilian use is the rifled barrel; gunsmiths in Germany were proficient in this technology as early as 1530,⁵¹ and the first patent for such was issued as early as 1635.⁵² Yet rifles were not widely accepted for military use for centuries after that. While rifles were successfully employed during the French and Indian War and the American Revolutionary War in North America,⁵³ the British were still relying on the smoothbore Brown Bess as their standard infantry arm at

47. *Assault Weapons and Accessories in America*, *supra* note 43.

48. KLECK, *supra* note 38, at 70.

49. *See generally* Dennis Chapman, Features and Lawful Common Uses of Semi-Automatic Rifles 88-91 (July 16, 2019) (unpublished ms.) (on file with SSRN), <https://ssrn.com/abstract=3436512> [<https://perma.cc/VS5V-RSWK>].

50. DEP’T OF THE ARMY, FIELD MANUAL 23-71, RIFLE MARKSMANSHIP, 225 (December 1966).

51. *See* HARSANYI, *supra* note 29, at 29.

52. C.H.B PRIDHAM, SUPERIORITY OF FIRE: A SHORT HISTORY OF RIFLES AND MACHINE-GUNS 8 (Hutchinson’s Sci. and Tech. Publications 1945).

53. *Id.* at 8–10.

Waterloo.⁵⁴ Only in the Crimean War in 1854 was the rifle first “generally used” as a standard infantry arm by Great Britain.⁵⁵

The introduction of semi-automatic firearms in the civilian market substantially preceded their military adoption. A “gas-operated semi-automatic pistol” emerged as early as 1863.⁵⁶ “[T]he earlier [semi-]automatic rifles of the beginning of the modern type” were introduced by the mid-1890s,⁵⁷ decades before the U.S. adopted the M1 Garand, the first semi-automatic rifle adopted as a standard infantry arm.⁵⁸ Even the AR-15 itself, as David R. Hughes reports, owes its existence to civilian visionaries with civilian shooting applications in mind.⁵⁹ Though Eugene Stoner is famously credited with its invention, the AR-15 ultimately owes its space-age construction of aluminum, fiberglass, and polymers to avid hunter and firearms enthusiast Richard Boutelle, President of Fairchild Aircraft. Boutelle, among others, tasked Fairchild’s Armalite Division with creating a line of high-end, lightweight sporting rifles made from the materials used in aircraft construction.⁶⁰ Only after the unexpected success of Armalite’s AR-5 survival rifle did Armalite defer commercial work in favor of the military market.⁶¹ Notwithstanding its distinctive appearance and unique aluminum, fiberglass, and plastic construction, the AR-15’s most groundbreaking feature was, arguably, its ammunition—the intermediate .223 Remington and 5.56mm NATO rounds. Yet, even this feature was derived from a civilian antecedent.⁶² It was based on the .222 Remington varmint cartridge developed in 1950 by Remington’s Mike Walker.⁶³

Only in the 20th century did automatic and selective fire technology—the first shoulder-fired weapons technology (with trivial exceptions) conceived solely for military applications—become firmly established. Selective fire technology gives the modern infantryman a capability not present in any civilian firearm: the option of firing either semi-automatically, that is, one round per pull of the trigger (a capability

54. *Id.* at 11.

55. JOHN A. ENGLISH & BRUCE I. GUDMUNDSSON, ON INFANTRY 12 (Praeger Publishers rev. ed. 1994); PRIDHAM, *supra* note 52, at 12.

56. Wilson, R.K., *Textbook of Automatic Pistols*, Small Arms Tech. Pub. Company, Plantersville, South Carolina, 1943; reprinted by Palladium Press for the Firearms Classics Library, 1999, p. 53.

57. MELVIN M. JOHNSON JR. & CHARLES T. HAVEN, AUTOMATIC ARMS: THEIR HISTORY, DEVELOPMENT AND USE 51 (William and Morrow Co. 1941).

58. *Id.* at 65–66.

59. DAVID R. HUGHES, THE HISTORY AND DEVELOPMENT OF THE M16 RIFLE AND ITS CARTRIDGE 254–55 (1990).

60. *Id.*

61. *Id.*

62. *Id.* at 23.

63. *Id.*

readily available in civilian firearms for well over a hundred years), or in automatic mode, firing multiple rounds with a single pull of the trigger.

Implicit in the characterization of the AR-15 as a “weapon of war” is the assumption that it bears certain features useful in combat, and that those features are also useful in crime.⁶⁴ This, however, is faulty reasoning: “the logical problem with this position is that whatever technical attributes guns have that make them suitable for committing crimes necessarily make them useful in a variety of lawful applications.”⁶⁵ Yet, the error is even greater than that. While capabilities that make a firearm useful in crime may also be useful in other shooting applications, the reverse is not true. This paper will demonstrate how applications useful in legitimate shooting activities are often, even usually, irrelevant in criminal applications.

IV. MISCONSTRUING THE AR-15 AS A MILITARY WEAPON

In *Kolbe v. Hogan*, the U.S. 4th Circuit Court of Appeals observed that “soldiers and police officers are often advised to choose and use semiautomatic fire, because it is more accurate and lethal than automatic fire in many combat and law enforcement situations.”⁶⁶ The court’s assertion that semi-automatic fire may be more “accurate and lethal” than automatic fire is very dubious, especially as it regards lethality.⁶⁷ The court

64. Christopher S. Koper, William D. Johnson, Jordan L. Nichols, Ambrozie Ayers & Natalie Mullins, *Criminal Use of Assault Weapons and High-Capacity Semiautomatic Firearms: an Updated Examination of Local and National Sources*, 95 J. OF URB. HEALTH 313, 313–14 (2018); Jeffrey A. Roth & Christopher S. Koper, *Impacts of the 1994 Assault Weapons Ban: 1994-96*, NAT’L INST. OF JUST. RES. IN BRIEF, Mar. 1999, at 2.

65. KLECK, *supra* note 38, at 14.

66. *Kolbe v. Hogan*, 849 F.3d 114, 125 (4th Cir. 2017).

67. The Court’s assertion that semi-automatic fire is more accurate and lethal than automatic fire cannot bear scrutiny, as demonstrated by the effect of fully automatic machine guns in battle. See, e.g., PRIDHAM, *supra* note 52, at 47., describing an attack by a company of 200 Japanese troops upon a Russian position defended by two Maxim machineguns during the Russo-Japanese War, in which “the Japanese firing line was literally swept away;” see also John Ellis, writing of the Battle of the Somme, that “As before, British tactics were based upon the infantry charge, and the German upon the deployment of large numbers of machine guns. The forward positions were almost entirely entrusted to the battle-hardened machine gunners, whilst the bulk of the ordinary infantry was held further back to counter-attack or mop up the few enemy who managed to get beyond the front line;” Ellis then quotes Lloyd George as observing that “[o]ur men advanced against the most terrible machine gun fire ever directed against troops ... and fell by the thousands in every attack.” JOHN ELLIS, *THE SOCIAL HISTORY OF THE MACHINE GUN* 141 (Johns Hopkins Univ. Press paperback ed. 1986). The fully automatic machinegun retains pride of place in the infantry even today, thus refuting the Court’s conclusion that automatic fire is interchangeable with or even inferior to that of semi-automatic weapons: “The machinegun is one of the most

does correctly note that semi-automatic fire is the most appropriate mode of fire for individual soldiers and police in many law enforcement and military scenarios. From this, the court leaps to the conclusion that, because semi-automatic firing capability has military value, it is therefore unprotected by the Second Amendment. The court misapprehends the situation; however, semi-automatic fire is useful in law enforcement and military situations because it is useful in all legitimate shooting applications. This is especially true about the AR-15, as well-stated by John Stokes in the left-leaning *Vox*:

In the pre-AR-15 era, if you wanted a gun for shooting little groundhogs, a gun for shooting giant feral hogs, and a gun for home defense, you'd buy three different guns in three different calibers and configurations. With the AR platform, a person with absolutely no gunsmithing expertise can buy one gun and a bunch of accessories, and optimize that gun for the application at hand ... So cops and civilians buy AR-15s because that one gun can be adapted to an infinite variety of sporting, hunting, and use-of-force scenarios by an amateur with a few simple tools ... **Anyone who tells you that the AR-15 is bad for hunting and home defense has absolutely no idea what they're talking about because by definition an AR is a gun that can be exquisitely adapted for those niches and many others** ... The AR-15's incredible flexibility, accuracy, and ease-of-use combine with its status as the most thoroughly tested and debugged firearm in military history to make it massively popular with shooters of all stripes, **from hunters to home defense buyers to competitors to police**.⁶⁸

The same cannot be said about automatic fire; it exists for the purely military purpose of achieving fire superiority over an enemy force. Automatic and selective fire is **the only significant uniquely military firearms feature**. Stokes observes that “[t]here is no conceivable

potent weapons in a rifle company’s armory. It can support the rifleman with a heavy volume of close and continuous fire in both the attack and the defense” (Major Harlie R. Treat, *Machinegunners*, Infantry, Nov-Dec 1983, page 38); “The two M60 machine guns in the light infantry platoon provide a significant portion of the unit’s firepower” (FM 7-70, *Light Infantry Platoon/Squad*, Headquarters, Dep’t of the Army, September 1986, page 7-1); “The machine gun ... is the platoon leader’s means to decisively influence a combat situation” (*Id.* at 7-35); “Whatever technique is in the defense, machine guns are the heart of it” (*Id.* at 7-41).

68. John Stokes, *Why millions of Americans – including me – own the AR-15*, VOX.COM, (June 20, 2016, 11:00 AM) <https://www.vox.com/2016/6/20/11975850/ar-15-owner-orlando> [<https://perma.cc/T2G6-PHKF>] (emphasis added).

circumstance in which a police officer — not even a SWAT team member — would need to mow down hordes of people.”⁶⁹ However, this cannot be said about infantry combat. Combat is a truly distinctive shooting application, wherein combatants employ fire and movement to gain advantage over another force.⁷⁰ A key assumption in planning for infantry combat is that the opposing force will have the ability to offer meaningful resistance.⁷¹ Overcoming such resistance is the purpose of automatic fire and selective fire capability. On the offense, automatic fire enables an attacker to direct such a high volume of fire at that enemy that he is *suppressed*—that is to say, the intensity of the attacker’s fire materially degrades the defender’s ability to return effective fire or to maneuver to counter the attack.⁷² Individual riflemen in combat often engage the enemy in semi-automatic mode. However, that changes when they find themselves acting in a support by fire (SBF) role, suppressing an enemy position so that a maneuvering element can destroy it; as Conrad and Tinsley explain,

The SBF element’s focus is to gain fire superiority and cover the maneuver of the assaulting force as it gains a foothold onto an objective. Establishing the SBF is as critical to the deliberate attack as conducting the assault. Without the SBF, the assaulting element has to contend with an enemy that is presented with only one problem. When the assault element is covered by the SBF element, the enemy is now presented with a dilemma.⁷³

In the military context, a “dilemma” is:

a situation in which the enemy is presented with two or more equally bad alternatives . . . When presented with a dilemma, an enemy has two reactions. The first reaction is not knowing what to do as he attempts to decide between equally bad options. This effect is commonly termed “fixed.”⁷⁴

69. *Id.*

70. SFC Carter H. Conrad & SFC Johnny Tinsley, *The Art of Support by Fire*, 103 INFANTRY 2, Apr. - June 2014, at 28.

71. Dennis P. Chapman, *Tactical Errors in the Dismounted Fight*, 113 ARMOR 20, 22 (July-Aug. 2004).

72. *Id.* at 20–22; Dennis P. Chapman, *An Element of Strength: Reinventing Small-Unit Training*, 113 ARMOR 35, 36–37 (May-June 2004).

73. Conrad & Tinsley, *supra* note 70, at 28.

74. DEP’T OF THE ARMY, FIELD MANUAL 3-21.8 (FM 7-8), THE INFANTRY RIFLE PLATOON AND SQUAD 1-22 (28 Mar. 2007).

The sources quoted above are all from the 21st Century, but this concept is not a new one. As early as 1945, the staff of the Allied 15th Army Group, under Lieutenant General Mark Clark in Italy, described what happens when a military unit allows itself to be caught on the horns of such a dilemma:

Troops that . . . permitted themselves to be pinned down were inevitably subjected to deadly mortar and artillery concentrations which very often caused excessive casualties . . . Our troops had a strong inclination, when fired upon, to dig in without returning the fire, inasmuch as they could see no suitable targets at which to fire. When they did return fire into the hostile area, the German fire either materially decreased or stopped. Some units quickly learned that the proper procedure to take, when fired upon, was to return fire promptly, deploy a force sufficient to overcome the resistance, and keep on going.⁷⁵

Conversely, the defender uses automatic fire to attempt to break the attacker's momentum by confronting him with a curtain of interlocking fires so intense that he cannot continue his attack without excessive losses.⁷⁶ As the Canadian officer, historian, and military theorist, John A. English, explained:

A commander has a moral responsibility to keep his men alive and [] no commander is ever justified in launching his troops to a direct attack on an enemy firmly in position. To do so under modern conditions would be to trigger, from even a dozen enemy armed with assault rifles, an intense fire of roughly 6,000 rounds a minute during the last few hundred yards.⁷⁷

In infantry combat, “mow[ing] down lots of people” is wholly in order and calls for a uniquely military capability: automatic or selective fire.

75. G-3 SECTION HEADQUARTERS 15 ARMY GROUP. ITALY, A MILITARY ENCYCLOPEDIA BASED ON OPERATIONS IN THE ITALIAN CAMPAIGNS 169 (1943-1945).

76. Chapman, *supra* note 72, at 37.

77. ENGLISH & GUDMUNDSSON, *supra* note 55, at 222.

V. VIOLENT CRIME AND COMBAT ARE NOT EQUIVALENT PHENOMENA

In contrast to infantry combat, crime is an entirely different phenomenon wherein the assailant assumes that his victim cannot offer meaningful resistance. A criminal seeks out weak, isolated, vulnerable victims who pose little likelihood of resisting the attack.⁷⁸ Where the intended victim is able to place the attacker in an “initiative/armament deficit,” thereby demonstrating that he can resist effectively, it is likely that the attacker will forgo that target, knowing that “there is probably someone a couple of blocks away who is unprepared and will make a far easier victim.”⁷⁹ Not only does this paradigm make automatic fire capability superfluous to a criminal, even a mass shooter, but it also renders all the firearms features that gun control advocates find so disturbing irrelevant in the criminal context. As Craig Douglas has noted, a criminal approaches his presumptively helpless target with two profound advantages. The first is “unequal initiative,” in that he chooses the time, place, and manner of his attack so as to place his victim at maximum disadvantage. The second is “unproportional armament,” bringing to bear some sort of weapon—often, but not always, a firearm—to multiply his strength vis-à-vis the victim and to compel compliance.⁸⁰ *Under these circumstances, the specific features or qualities of any particular firearm become irrelevant.* In the criminal attack scenario, any marginal improvement in the effectiveness of one firearm versus another is simply subsumed within the overwhelming imbalance of power in the attacker’s favor created by his possession of nearly any type of firearm at all.

The converse, however, does not follow. Having been taken at a disadvantage, the victim requires more than mere parity with his attacker to survive. Instead, he or she requires superiority in some capacity to break the assailant’s momentum and regain the initiative. The most efficacious means to accomplish this is a firearm superior in quality and effectiveness to the attacker’s weapon.

VI. IS THE AR-15 UNIQUELY SUITED TO KILLING LARGE NUMBER OF PEOPLE?

Gun control advocates argue that the AR-15 is particularly well-suited to produce a high volume of fire and kill lots of people, making them ideal for mass shootings.⁸¹ They typically ascribe this supposed excessive

78. CRAIG DOUGLAS, THE CRIMINAL ASSAULT PARADIGM, IN STRAIGHT TALK ON ARMED DEFENSE 92, 94 (Massad Ayoob ed., 2017).

79. *Id.* at 96.

80. *Id.* at 92–104.

81. See, e.g., Tim Dickinson, *All-American Killer: How the AR-15 Became Mass Shooters’ Weapon of Choice*, ROLLING STONE (Feb. 22, 2018 4:20PM ET), <https://www.rollingstone.com/politics/politics-features/all-american-killer-how-the->

lethality to pistol grips, hand-guards that encircle the barrel (“barrel shrouds”),⁸² and so-called “high capacity” magazines,⁸³ all of which gun control advocates allege enable a shooter to “spray an area and kill large amounts of people,” by stabilizing the weapon and protecting the shooter’s hand from the heat generated by rapid firing.⁸⁴

This claim does not withstand scrutiny. A comprehensive review of U.S. Army marksmanship doctrine from 1923 through 2012 demonstrates that neither pistol grips nor “barrel shroud” hand-guards are associated with spraying fire, from the hip, or otherwise.⁸⁵ “Barrel shroud” handguards are old technology. One of the earliest rifles equipped with them was the Short Magazine Lee-Enfield (S.M.L.E.), introduced around the turn of the 20th Century.⁸⁶ These rifles served British forces through both World Wars. The S.M.L.E. was equipped with such a hand-guard to protect the soldier’s hand from the heat generated by rapid firing.⁸⁷ But this rather debunks the gun control advocates’ claims than confirm them. The “rapid firing” of the S.M.L.E. was only 15 rounds per minute, or one round every four seconds. This is a far cry from the fantastical rates of fire mistakenly attributed to the AR-15 by gun control advocates, as noted below.^{88, 89} Furthermore, a 1975 Rock Island Arsenal study on the M16 rifle found that the barrel can reach temperatures high enough to cause injury at rather low rates of fire, even at some points along the barrel, after the first round fired.⁹⁰ Thus, contrary to

ar-15-became-mass-shooters-weapon-of-choice-107819/ [https://perma.cc/A36F-WLXQ].

82. The term “barrel shroud” does not appear in any U.S. Army firearms literature, nor the literature of the shooting sports community, so far as I am aware. It appears to be a phrase coined by legislators, regulators, or gun control activists, rather than by those who actually design and use firearms.

83. COUNCIL OF THE DIST. OF COLOMBIA COMM. ON PUBLIC SAFETY AND THE JUDICIARY, REP. ON B. 17-843, “FIREARMS REGISTRATION AMENDMENT ACT OF 2008” at 7 (2008).

84. *Id.*; Johnathan Lowy, et al., *Panel 2: Are Semiautomatic Rifles, aka “Assault Weapons,” Protected by the Second Amendment?*, THE FEDERALIST SOC’Y, THE SECOND AMENDMENT IN THE NEW SUPREME COURT (Jan. 15, 2019), <https://fedsoc.org/conferences/the-2nd-amendment-in-the-new-supreme-court/#agenda-item-panel-2-are-semiautomatic-rifles-aka-assault-weapons-protected-by-the-second-amendment>.

85. *See* Chapman, *supra* note 49, at 34–68, for a more detailed account of the U.S. Army marksmanship doctrine as it relates to pistol grips and “barrel shrouds.”

86. PRIDHAM, *supra* note 52, at 16–17.

87. *Id.* at 17.

88. *Id.* at 56–57, 67.

89. As a bolt action rifle, the S.M.L.E. can hardly be said to be capable of “spraying” fire anyway.

90. RONALD E. ELBE, EXTERNAL BARREL TEMPERATURE OF THE M16A1 RIFLE 15–21 (1975); J.C. Lawrence & J.P. Bull, *Thermal Conditions Which Cause*

the claims of gun control advocates, “barrel shrouds” are an appropriate safety feature in any legitimate shooting application, not just combat or mass shootings.

While United States Army doctrine has provided for quick-kill, hip-firing techniques for all the shoulder-fired arms adopted since World War I, there is no correlation between the existence of such techniques and the presence of pistol grips or “barrel shroud” hand-guards on the weapons.⁹¹ For example, one of the United States Army’s earliest shoulder fired automatic weapons was the selective fire M1918 Browning Automatic Rifle (BAR). It had neither a “barrel shroud” nor a pistol grip, but its training manual provided for “assault fire” from the hip.⁹² The doctrine for the semi-automatic M1 Garand and M1 Carbine, as well as for the selective fire M14, all contained hip-firing techniques. Yet while all these rifles had “barrel shrouds,” none of them had pistol grips in their standard configuration.⁹³ While the doctrine for both the Thompson and M3 submachine guns provided for hip firing and both had pistol grips, neither had a “barrel shroud.”⁹⁴ Furthermore, even to the extent that military doctrine provided for hip firing techniques, these were niche techniques that received very little attention or training. In fact, the doctrine sometimes denigrated them. One doctrinal manual for the Thompson submachinegun allowed for firing “from the hip while marching,” but dismissed it as a “relatively ineffective” technique that “should rarely be used.”⁹⁵ The doctrine for the M3 “Grease Gun” allowed for hip firing, but cautioned that “the soldier must have a great deal of practice before he can do accurate shooting” in this manner.⁹⁶

Skin Burns, 5 ENGINEERING IN MED. 61, 61 (1976); A. R. Moritz & F. C. Henriques, *Studies of Thermal Injury*, 1974 AM. J. OF PATHOLOGY 695, 711.

91. War Dep’t Training Regulation (TR) 150-30, Marksmanship, Automatic Rifle, at 23 (November 21, 1923).

92. *Id.* at 23.

93. DEP’T OF ARMY FIELD MANUAL 23-5, U.S. RIFLE CALIBER .30, M1, at 4 (May 1965); DEP’T OF ARMY FIELD MANUAL 23-5, U.S. RIFLE CALIBER .30, M1, at 106–110 (Sept. 1958); WAR DEP’T BASIC FIELD MANUAL, U.S. CARBINE, CALIBER .30, M1, at 2 (May 20, 1942); DEP’T OF ARMY FIELD MANUAL 23-7/DEP’T OF THE AIR FORCE MANUAL 50-4, CARBINE CALIBER .30 M1, M1A1, M2, AND M3, at 1–6 (Jan. 1952); DEP’T OF ARMY FIELD MANUAL 23-8, U.S. RIFLE 7.62-MM M14, at 11, 25 (Dec. 1959); DEP’T OF ARMY FIELD MANUAL 23-8, US M14 AND M14A1 RIFLES, at 5 and 133 (15 Apr. 1974).

94. WAR DEP’T FIELD MANUAL 34-35, THOMPSON SUBMACHINE GUN, CALIBER .45, M19281A, WITH CHANGES 1, 2, 3, & 4, at 2 (31 December 1941); FM 23-41, SUBMACHINE GUNS CALIBER .45 M3 AND M3A1, at 5, 55 (July 1957) [hereinafter FM23-41].

95. WAR DEP’T FIELD MANUAL 23-40, THOMPSON SUBMACHINE GUN, CALIBER .45, M19281A, WITH CHANGES 1, 2, 3, & 4, at 35 (31 Dec. 1941).

96. FM 23-41, *supra* note 94, at 54.

Were the AR-15's distinctive pistol grip and hand-guards intended to facilitate "spraying fire" from the hip, one would expect U.S. military doctrine to have further emphasized such firing techniques with the introduction of the semi-automatic AR-15's selective-fire military analogue, the M16. Yet the opposite happened: while Army marksmanship doctrine retained them, it diluted the already limited importance of hip-firing techniques by incorporating quick fire techniques from the shoulder not long after the M16's introduction.⁹⁷ By 2012, the Army had effectively admitted to the obsolescence of hip-firing firing techniques by acknowledging the primacy of firing from the shoulder, noting that "[m]odern short-range combat (SRC) techniques emphasize carrying the rifle with the butt high, so the rifle sights can be brought into display as quickly as firing a hasty unaimed shot. In extremely dangerous moments, special reaction teams (SRTs) commonly advance with weapons shouldered."⁹⁸ The Marine Corps marksmanship manual does not include any reference to hip firing at all.⁹⁹

The principal voices popularizing this myth of spraying fire from the hip are governmental authorities seeking to justify firearms restrictions,¹⁰⁰ gun control advocates, and the creators of pop culture fiction. Examples of the latter include 1967's *The St. Valentine's Day Massacre*, wherein Al Capone's "Tommy Gun" wielding henchmen mow down his

97. 50359 ARMY TRAINING TEXT 23-71-1, PRINCIPLES OF QUICK KILL 13 (12 May 1967); JAMES W. DEES, GEORGE J. MAGNER & MICHAEL R. MCCLUSKEY, HUMAN RESOURCES RESEARCH ORGANIZATION TECHNICAL REPORT 71-4, at 15, AN EXPERIMENTAL REVIEW OF BASIC COMBAT RIFLE MARKSMANSHIP: MARKSMAN, PHASE I, at 15 (1971); DEP'T OF ARMY FIELD MANUAL 23-8, M14 AND M14A1 RIFLES, AND RIFLE MARKSMANSHIP, at 152 (15 April 1974); FM 23-9, M16A1 RIFLE AND RIFLE MARKSMANSHIP, at 151-53 (June 1974); DEP'T OF ARMY FIELD MANUAL 23-9, M16A1 AND M16A2 RIFLE MARKSMANSHIP, at 4-12 (3 July 1989).

98. DEP'T OF ARMY FIELD MANUAL 3-22.9(FM 23-9), RIFLE MARKSMANSHIP M16A1, M16A2/3, M16A4, AND M4 CARBINE, at 7-17 (April 2003) (C3 April 2005); DEP'T OF ARMY FIELD MANUAL 3-22.9, RIFLE MARKSMANSHIP M16-/M4-SERIES WEAPON, at 7-20 (August 2008) [hereinafter FM 3-22.9] (emphasis added).

99. US MARINE CORPS, MCRP 3-01A, RIFLE MARKSMANSHIP (11 Oct. 2012).

100. COUNCIL OF THE D.C., COMM. ON PUB. SAFETY AND THE JUDICIARY, REP. ON BILL 17-843, *FIREARMS REGISTRATION AMENDMENT ACT OF 2008*, 7 (2008). "As stated in the above paragraph, assault weapons are military-style weapons made for offensive military use. They are designed with military features to allow rapid and accurate spray firing. They are not designed for sport, but to kill people quickly and efficiently. Assault weapons also have features such as pistol grips and the ability to accept a detachable magazine. Pistol grips help stabilize the weapon during rapid fire and allow the shooter to spray-fire from the hip position." *Id.* (emphasis added).

enemies,¹⁰¹ and 1983's *Scarface*, where Al Pachino's Tony Montana cuts down his enemies with an M16 in the film's climactic scene.¹⁰²

This is not the only false claim about the capabilities of the AR-15 in circulation. After the Pulse Nightclub shooting, Congressman Alan Grayson claimed that the AR-15 could fire 700 rounds per minute.¹⁰³ Similarly, the 4th Circuit in *Kolby v. Hogan* absurdly claimed that there is little difference between automatic and semi-automatic fire.¹⁰⁴ Theoretically, the rate at which a semi-automatic weapon can fire is limited by the speed of its recoil cycle, but the rate at which a shooter can induce his weapon to expend ammunition is of little importance in itself.¹⁰⁵ As Johnson and Haven noted in 1941, what really matters is how fast one can fire *and still hit targets*.¹⁰⁶ As they observed, "[i]t is customary to consider rapid fire in terms of how many shots are fired in one minute. **This is unreal and very misleading.** The true criterion and measure of efficiency are expressed in terms of how many shots are necessary to fire the necessary number of effective shots."¹⁰⁷

Referring again to the semi-automatic AR-15's selective-fire military analogue, the M16, the maximum *effective* semi-automatic rate of fire is 45 rounds per minute and the sustained rate of fire of 12–15 rounds per minute.¹⁰⁸ Even if a shooter were able to replicate the fantastical rates of fire attributed to the semi-automatic AR-15 by Representative Grayson and others, his fire would be ineffective. Semi-automatic rifles have greater effective rates of fire than bolt action rifles, but they are still limited.¹⁰⁹ After conducting a study comparing the effective rates of fire for bolt action and semi-automatic rifles, Johnson and Haven found that firing a semi-automatic rifle at 10 rounds per 1.5 seconds produced *unaimed fire*.¹¹⁰ This derives from the fundamental principles of marksmanship.¹¹¹ These principles include steady position, sight picture, breath control, and trigger squeeze.¹¹² A shooter attempting to replicate fully automatic fire with a

101. THE ST. VALENTINE'S DAY MASSACRE (Twentieth Century Fox 1967).

102. SCARFACE (Universal Pictures 1983).

103. Douglas Ernst, *Alan Grayson claims AR-15s can fire '700 rounds in a minute' after Orlando attack*, THE WASHINGTON TIMES (Monday, June 13, 2016), <https://www.washingtontimes.com/news/2016/jun/13/alan-grayson-claims-ar-15-rifles-can-fire-700-round/> [<https://perma.cc/Z7G2-NMH9>].

104. *Kolbe v. Hogan*, 849 F.3d 114, 125 (4th Cir. 2017).

105. JOHNSON & HAVEN, *supra* note 57, at 189.

106. *Id.*

107. *Id.* (emphasis added).

108. DEP'T OF ARMY FIELD MANUAL 3-22.9(FM 23-9), RIFLE MARKSMANSHIP M16A1, M16A2/3, M16A4, AND M4 CARBINE, at 2-1 (Apr. 2003) [hereinafter FM 3-22.9(FM23-9)].

109. JOHNSON & HAVEN, *supra* note 57, at 189–90.

110. *Id.* at 190.

111. FM 3-22.9, *supra* note 98, at 4–16.

112. *Id.*

semi-automatic rifle would, through the rapidity of his actions, fail to apply these principles correctly. Specifically, he or she would fail to properly apply the trigger squeeze fundamental, which requires careful, even depression of the trigger.¹¹³

The most important single factor in marksmanship is trigger squeeze. Everything about your position and aim may be perfect, but, unless you squeeze the trigger correctly, your shot will not go where you have aimed ... if you jerk the trigger, you lose control ... jerking the trigger will disturb the sites. Even a slight movement will spoil an otherwise good shot.¹¹⁴

A shooter attempting to replicate automatic fire with a semi-automatic rifle would jerk the trigger, moving the rifle slightly off target, thereby spoiling his aim. A selective fire rifle, such as the M16 in automatic mode, continuously fires rounds as long as the trigger remains depressed.¹¹⁵ This eliminates the jerking effect of rapid, repeated trigger pulls and minimizes errors in applying the other marksmanship techniques while firing on automatic.

VII. “HIGH CAPACITY” MAGAZINES: SUPERFLUOUS FOR CRIMINALS, ESSENTIAL FOR SELF DEFENSE.

One feature that might seem at first blush to materially enhance the lethality of a semi-automatic firearm are so-called “high capacity” magazines. This is based on the assumption that a shooter equipped with such magazines can fire more rounds without reloading, and thereby inflict more casualties.¹¹⁶ However, upon scrutiny this hypothesis fails. Former Indiana Sheriff Ken Campbell, in a 2013 video demonstration, compared the amount of time that it took both experienced and inexperienced shooters to expend the same amount of rounds using different combinations of magazines of varying capacities.¹¹⁷ He also performed a demonstration

113. *Id.* at 4–23; DEP’T OF ARMY FIELD MANUAL 23-5, U.S. RIFLE CALIBER .30, M1, at 110 (Sept. 1958).

114. DEP’T OF ARMY FIELD MANUAL 23-7/DEP’T OF AIR FORCE MANUAL 50-4, CARBINE CALIBER .30 M1, M1A1, M2, AND M3, at 157 (Jan. 1952).

115. FM 3-22.9(FM23-9), *supra* note 108, at 4–8.

116. Gary Kleck, *Large-Capacity Magazines and the Casualty Counts in Mass Shootings: The Plausibility of Linkages*, 17(I) JUST. RESEARCH AND POL’Y 28, 44 (2016).

117. Billy Hallowell, *Sheriff Debunks Gun Magazine ‘Fallacies’ in This Viral Vid (Plus:His Response to Biden’s Shotgun Advice)*, *The Blaze*, (Mar. 1, 2013), <https://www.theblaze.com/news/2013/03/01/sheriff-debunks-fallacies-surrounding->

where he simulated a bystander attempting to disarm a shooter during the interval when the shooter changes magazines.¹¹⁸ Sheriff Campbell demonstrated that shooters of any skill level can change magazines so fast as to have no material impact upon the shooter's net rate of fire. Additionally, the demonstration showed that a shooter can change magazines fast enough to defeat any attempt to rush and disarm him.¹¹⁹ Commenting on firearms restrictions limiting magazine capacity to 10 rounds, self-defense and firearms expert Massad Ayoob observed that

Criminals bent on causing harm, on the other hand, even assuming they were impeded from obtaining magazines holding over ten rounds due to the ordinance, could simply arm themselves with multiple weapons, and often do. Criminals have time to assess and plan shootings, whereas victims do not. Whitman, the Texas Tower mass murderer, literally brought a large box of rifles, handguns, a shotgun and ammunition to his sniper perch. Harris and Klebold had four firearms between them at Columbine. Holmes in Aurora brought rifle, shotgun, and pistol into the theater ... The likelihood of the mass murderer arriving on scene with multiple firearms also largely negates the theory that with fewer rounds in the gun, the killer could be more easily disarmed and subdued by unarmed citizens when he first ran empty, before he could reload.¹²⁰

Given the alacrity with which attackers can change magazines, restrictions on magazine capacity are not an effective way of curbing the lethality of their attacks. However, while magazine capacity limits do little to constrain the damage done by criminal assailants, they do materially

gun-magazines-in-this-viral-vid-plus-his-response-to-bidens-shotgun-advice [https://perma.cc/6BNM-H4QZ].

118. *Id.*

119. Regrettably, Sheriff Campbell resigned his post in 2014 after it was revealed that he had been involved in an affair with a known prostitute. While this regrettable lapse certainly reflects upon Sheriff Campbell's personal and professional values and judgment, it says nothing about the efficacy of the demonstrations described here. See Diana Penner & Vic Ryckaert, *Boone County sheriff resigns amid prostitution investigation*, INDYSTAR. (9:22 p.m. ET Jun. 19, 2014), <https://www.indystar.com/story/news/crime/2014/06/19/boone-county-sheriff-resigns-amid-prostitution-probe/11015867/> (last updated 1:20 p.m. ET Jun. 20, 2014) [https://perma.cc/K55D-V7UY].

120. Declaration of Massad Ayoob in Support of Motion for Preliminary Injunction ¶¶ 19–22, at 7–8, S.F. Veteran Police Officers Ass'n v. City and Cty. of S.F., No. 13-CV-13-5351 (N.D. Cal. 2014).

impair the ability of peaceable citizens to defend themselves.¹²¹ Ayoob explains:

The homeowner who keeps a defensive firearm and is awakened in the night by an intruder is most unlikely to have time to gather spare ammunition. The sudden and unpredictable nature of such attacks, and their occurring in relatively confined spaces, generally do not permit gathering multiple firearms or magazines. Ideally, one hand would be occupied with the handgun itself, and the other, with a telephone to call the police. And, assuming they even had time for a magazine change, most people do not sleep wearing clothing that would allow them to stow spare magazines, etc. on their person. They would have only what was in the gun ... The virtuous citizen, . . . cannot practically be expected to have accessible that many guns or that much ammunition at a moment's notice. The victimized citizen is the one who is, therefore, most deleteriously impacted by the magazine capacity limitation. If he or she must use the gun to protect self and family, they will most likely have only the ammunition in the gun with which to fend off determined, perhaps multiple, attackers.^{122, 123}

121. *Id.* ¶¶ 17–23, at 6–8.

122. *Id.* ¶¶ 19–22.

123. Gun control advocates sometimes assert that 10 rounds ought to be enough to repel an attacker (for example, see Stephen King, *supra* note 41: “[i]f you can't kill a burglar with 10 shots, you need to go back to the shooting range.”) However, this is not a valid assumption. As shown by Marshall and Sanow, *post*, it often requires multiple rounds to stop an attacker. This is especially true where there are multiple assailants, and in such cases 10 rounds may not be nearly sufficient. See Stefani Okolie, *post*, reporting on a home invasion where “dozens of shots were fired” by home owner to repel five home invaders. See also the case of Susan Gonzalez and her husband, reported by Masaad Ayoob, who were confronted by two home invaders. Mrs. Gonzalez was armed with a Ruger 9mm pistol “designed to hold fifteen cartridges in the magazine and one more in the firing chamber,” but which due to legal restrictions was loaded with a 10 round magazine. By the time she had expended 10 rounds, she had gravely injured one attacker but the other was unhurt; he disarmed her and stole the couple's vehicle in which both suspects fled, leaving Mrs. Gonzalez and her husband lucky to be alive. Declaration of Massad Ayoob in Support of Motion for Preliminary Injunction, San Francisco Veteran Police Officers Ass'n, et al., v. The City and County of San Francisco, et al., U.S. District Court for the Northern District of California, San Francisco Division, Case No. 13-CV-13-5351, Document 17, filed December 27th, 2013, paragraphs 5 – 9.

Gary Kleck confirmed Sheriff Campbell's results.¹²⁴ In a 2016 study, Kleck reviewed 24 mass shootings in which the shooter's effective rate of fire could be ascertained.¹²⁵ In the mass shooting events he analyzed, the average rate of fire was slower than the time needed to change magazines.¹²⁶ Therefore, the changing of magazines did not reduce the attackers' net effective rate of fire at all.¹²⁷

Criminal assaults and military combat are not equivalent phenomena. Nonetheless, the law abiding citizen that hopes to cope successfully with a criminal attack can learn something from the American infantrymen who successfully coped with their own enemies in Italy, as noted by the staff of the 15th Army Group in the Italian Theater during the Second World War: "It was shown repeatedly that units which pressed their attack vigorously suffered far fewer casualties and were more uniformly successful than those which hesitated or stopped when fired upon."¹²⁸

It is here that a semi-automatic firearm equipped with a so-called "high capacity" magazine becomes essential to a peaceable citizen defending himself. These tools enable a law-abiding citizen to respond vigorously to his attacker with equal or greater force than the attacker has brought to bear. This gives the citizen the chance to wrest the initiative back away from the criminal assailant.

VIII. AR-15 RIFLES ARE COMMONLY USED FOR LAWFUL PURPOSES

So-called "assault" weapons and "high capacity" magazines are not necessary to execute mass shootings.¹²⁹ Christopher Koper's findings indicate that so-called "assault weapons" are used in as few as 18% and as many as 57% of mass shooting incidents.¹³⁰ Therefore, many of these attacks are carried out with other firearms.¹³¹ For example, shotguns were

124. Kleck, *supra* note 116.

125. *Id.*

126. *Id.*

127. Kleck, *supra* note 116, at 44.

128. G-3 SECTION HEADQUARTERS 15 ARMY GRP., IT., *supra* note 75.

129. See Matthew Larosiere, *Losing Count: The Empty Case for "High-Capacity" Magazine Restrictions*, LEGAL POL'Y BULL., No. 3, July 17, 2018, at 8, 10 (arguing that, because mass shooters plan ahead, they can execute their murderous motivations using any weapon of choice).

130. Christopher S. Koper, et al., *Criminal Use of Assault Weapons and High-Capacity Semiautomatic Firearms: An Updated Examination of Local and National Sources*, J. URB. HEALTH 313, 317–18, tbl.2 (2018).

131. Statista Research Dep't, *Weapon Types Used in Mass Shootings in the United States Between 1982 and February 2020*, STATISTA (May 4, 2020),

used in the Washington Navy Yard and Annapolis Gazette attacks.¹³² Additionally, firearms are not the only weapons by which a spree killing can be executed. In Eighteenth and Nineteenth Century Malay culture, men would suddenly embark upon mass killing sprees, armed only with edged weapons.¹³³ This was known as the *amok* phenomenon.¹³⁴

Not only are American gun owners confronted with a flood of false and deceptive information about the AR-15 from the gun control lobby, but they are also subject to a veritable gaslighting campaign.¹³⁵ Gun control advocates such as Senator Diane Feinstein claim that the AR-15 is not commonly used for lawful purposes.¹³⁶ The AR-15 is only the *latest* target of this kind of advocacy. As Kleck has observed:

many gun law proponents have narrowed their political efforts, targeting specific types of guns, which they argue are “good for only one thing – to kill.” These proponents differentiate “good” (or at least not-so-bad) types of guns, like the old family deer rifle, from “bad” types of guns. At various times, the especially dangerous, “bad” subcategory has been (1) handguns, (2) the cheap, small handguns known as “Saturday Night Specials,” (3) so-called “assault rifles,” (4) machine guns, and (5) plastic guns. Proponents argue that these weapons are only useful for committing crimes, and sometimes even imply that they are never used

<https://www.statista.com/statistics/476409/mass-shootings-in-the-us-by-weapon-types-used/> [https://perma.cc/A454-HZQ5].

132. JOHN M. RICHARDSON, DEP’T OF THE NAVY, REPORT OF THE INVESTIGATION INTO THE FATAL SHOOTING INCIDENT AT THE WASHINGTON NAVY YARD ON SEPTEMBER 16, 2013 AND ASSOCIATED SECURITY, PERSONNEL, AND CONTRACTING POLICIES AND PRACTICES 2, 40 (Nov. 8, 2013); Chase Cook, *Man Charged in Capital Gazette Shooting Asks for Time to Consider Insanity Plea*, CAPITAL GAZETTE (Aug. 15, 2018), <https://www.capitalgazette.com/news/crime/ac-cn-ramos-plea-0816-story.html> [https://perma.cc/XZY5-P5H9].

133. JOHN C. SPORE, RUNNING AMOK: AN HISTORICAL INQUIRY (Ohio Univ. Ctr. for Int’l Studies, 1988).

134. *Id.*

135. See Emily Miller, *Here Are the 5 Worst “Fake News” Reports on Guns in 2017*, THE DAILY SIGNAL (Dec. 28, 2017), <https://www.dailysignal.com/2017/12/28/5-worst-fake-news-reports-guns-2017/> [https://perma.cc/QV2V-NZ25]; David Stitz, “Gaslighting” and Gun Control, THE INTELLIGENCER (Apr. 26, 2013, 12:15 A.M.), <https://www.theintell.com/88082ef6-f221-50cc-8f60-d2f9a51d2841.html> [https://perma.cc/K7SM-JW9H].

136. Stephanie Mencimer, *Kavanaugh Defends Opinion That Assault Weapons Are “Common” and Can’t Be Banned*, MOTHER JONES (Sept. 5, 2018), <https://www.motherjones.com/politics/2018/09/kavanaugh-defends-opinion-that-assault-weapons-are-common-and-cant-be-banned/> [https://perma.cc/RHZ2-37YT] (this page contains a tweet and video clip).

for any legitimate purposes. Because the guns have no legitimate purposes, it is argued, there can be no objection to outlawing them.¹³⁷

These claims are demonstrably false, as Ronald Turk, Associate Deputy Director (Chief Operating Officer) of the ATF, admitted in 2017:

Since the sunset of the Assault Weapons ban in 2004, the use of AR-15s, AK-style, and similar rifles now commonly referred to as “modern sporting rifles” has increased exponentially in sport shooting. These firearm types are now standard for hunting activities. ATF could re-examine its almost 20-year-old study to bring it up to date with the sport shooting landscape of today, which is vastly different than what it was years ago. Action shooting sports and organizations such as 3 Gun and the United States Practical Shooting Association (USPSA) have also drastically expanded in recent years. Restriction on imports serves questionable public safety interests, as these rifles are already generally legally available for manufacture and ownership in the United States.¹³⁸

The AR-15 is the most popular rifle for competition shooting and is thoroughly integrated into competition shooting,¹³⁹ including Civilian Marksmanship Program and National Rifle Association Service Rifle and High Power competitions;¹⁴⁰ United States Practical Shooting Association

137. KLECK, *supra* note 38, at 14.

138. RONALD TURK, BUREAU OF ALCOHOL, TOBACCO, FIREARMS AND EXPLOSIVES (ATF), OPTIONS TO REDUCE OR MODIFY FIREARMS REGULATION, 5 (Jan. 20, 2017).

139. It is not merely integrated into formal shooting competitions, but into the very fabric of recreational shooting. As my own observations show, the vast majority of rifles appearing at ranges for target shooting are AR-15s.

140. *See* NRA HIGH POWER RIFLE RULES, 7–8 (Nat’l Rifle Ass’n of Am., 2020); CMP HIGHPOWER RIFLE COMPETITION RULES, 33–36 (Civilian Marksmanship Program, 23d ed. 2019); Frank Melloni, *Intro to Service Rifle*, NRA SHOOTING SPORTS USA (June 5, 2019), <https://www.ssusa.org/articles/2019/6/5/intro-to-service-rifle> [<https://perma.cc/29FJ-LWQ2>]; SUSSA Staff, *supra* note 135; Serena Juchnowski, *Why Shoot High Power Service Rifle?* NRA SHOOTING SPORTS USA (Nov. 19, 2018), <https://www.ssusa.org/articles/2018/11/19/why-shoot-high-power-service-rifle/> [<https://perma.cc/4Z5M-LSJ3>]; Dennis Santiago, *What You Need to Know About High Power Rifle Competition*, NRA SHOOTING SPORTS USA (Sept. 18, 2018), <https://www.ssusa.org/articles/2018/9/18/what-you-need-to-know-about-high-power-rifle-competition/> [<https://perma.cc/SJ3B-6KN5>]; *See* SUSSA Staff, *10 Essential Items You Need to Get Started in High Power Rifle*, NRA SHOOTING SPORTS USA (Sept. 20, 2017), <https://www.ssusa.org/>

competitions;¹⁴¹ and Three Gun competitions.¹⁴² At the Three Gun competition, competitors shoot with pistol, shotgun, and rifle in the same course.¹⁴³

An unarmed person can be incapacitated or killed with relative ease with nearly any improvised weapon that comes to hand; because humans are relatively fragile compared to game animals, this tells us virtually nothing about hunting, one of the archetypal American firearms activities. Criticizing the methods used by Colonel Louis A. LaGarde in his classic 1914 study, *Gunshot Injuries*,¹⁴⁴ Evan P. Marshall and Edwin J. Sanow observed in 1992 that “steers are much harder to kill than humans, so applying the results of shooting animals to how particular handgun loads would work against humans was a hopeless task.”¹⁴⁵ Because wild animals are physically much more agile and robust than human beings, choice of firearm is much more important when hunting wild game than when committing violent crime against people.¹⁴⁶ As Montana hunting and fishing guide Norman Strung explained in 1973:

articles/2017/9/20/10-essential-items-you-need-to-get-started-in-high-power-rifle [https://perma.cc/2RN6-SDEA] (photo caption).

141. See Jake Martens, *The JP Enterprises PCC [Pistol Caliber Carbine] Midwest Championship*, 35 USPSA: THE OFFICIAL J. OF THE U.S. PRACTICAL SHOOTING ASS'N. STARTING PAGE NO., 40-42 (2019).

142. See Jeff Johnston and Phil Bourjaily, *The Beginner's Guide to 3-Gun Competition*, FIELD & STREAM (Sept. 30, 2019), <https://www.fieldandstream.com/beginners-guide-3-gun-competition/> [https://perma.cc/4AMT-6LMS].

143. See, e.g., John B. Holbrook, II, John Wick 3-Gun, USPCA Magazine, July/Aug. 2019, at 56; Aaron Bright, Review: A Couple of Carbines from Palmetto State Armory, USPCA Magazine, July/Aug. 2019, at 42; Troy McManus, Cochin in Steel Challenge, USPCA Magazine, July/Aug. 2019, at 9; Manny Bragg and Carole Bryant, The Glock 2018 Area 6 Championship, Frontsight, July/Aug. 2018, at 11; Jessica Nietzel, Multigun Nationals: What a Blast, Frontsight, July/Aug. 2018, at 16, 18, 20, 22; Kristine Hayes, The Science of Competition: Is Knowing How to Fail the Secret to Winning? Frontsight, July/Aug. 2017, at 18; Cora Maglaya, 2017 USPSA Armscor Rock Island Multigun National Championship, Frontsight, July/Aug. 2017, at 22. See also Frontsight, July/Aug. 1989; Frontsight, Mar./Apr. 1990; Frontsight, September/October 1991; Frontsight, July/Aug. 2001; Frontsight, July/Aug. 2002; Frontsight, Mar./Apr. 2010; Frontsight, Nov./Dec. 2010; Frontsight, Sept./Oct. 2014; Frontsight, July/Aug. 2015; Frontsight, July/Aug. 2016; Frontsight, May/June 2017; Frontsight, July/Aug. 2017; Frontsight, July/Aug. 2018 (covers).

144. LOUIS A. LA GARDE, GUNSHOT INJURIES: HOW THEY ARE INFLICTED, THEIR COMPLICATIONS AND TREATMENT. 43 (William Wood & Co., 2d ed. 1916). Le Garde used animals and cadavers to evaluate the lethality of various handgun calibers and loads.

145. EVAN P. MARSHALL & EDWIN J. SANOW, HANDGUN STOPPING POWER: THE DEFINITIVE STUDY 13 (Paladin Press, 1992).

146. See Will Drabold, *Here Are 7 Animals Hunters Kill Using an AR-15*, TIME (July 6, 2016, 12:13 P.M.), <https://time.com/4390506/gun-control-ar-15->

[t]hat kind of country you are hunting in should be the determining factor in your choice of a rifle rather than the species you are hunting or the size of your quarry. This is true of the caliber, the type of sight to use, and the action of the weapon.¹⁴⁷

On the other hand, nearly any firearm will suffice in the hands of a criminal to kill as many people as he wants.¹⁴⁸ Contrary to the perceptions of some, semi-automatic rifles have long been recognized as superior hunting instruments in appropriate settings. Strung notes,

Actions include bolt, lever, pump, and [semi]automatic. Because of the sudden snap-shot nature of hunting deer in brushy country, the bolt action is the least desirable for this situation. . . . I also find this problem with the lever actions . . . Personally, I favor the [semi]auto in the woodlands . . . I find being able to squeeze off four fast shots . . . a real advantage.¹⁴⁹

As AR-15 has become more popular generally, it has also become increasingly popular as a hunting platform.¹⁵⁰ In fact, Colt marketed the AR-15 as a “superb hunting partner” when it introduced the rifle to the civilian market in 1964.¹⁵¹ *Time* recently profiled several hunters who use the AR-15 in various calibers to hunt everything from jackrabbits to elk,¹⁵² and *AR15Hunter.com* describes the use of the AR-15 as a hunting implement.¹⁵³ The AR-15 and other semi-automatic carbines are also increasingly the firearm of choice for many as a home defense weapon.¹⁵⁴

semiautomatic-rifles/ [https://perma.cc/UJF8-28ZZ] (recognizing various gun choices to be used for hunting different wild animals and noting the agility of coyotes and the robust nature of boars).

147. STRUNG, *supra* note 31, at 168–69.

148. See Larosiére, *supra* note 129 (arguing that a murderer may use any firearm to kill).

149. *Id.* at 174.

150. See Drabold, *supra* note 146.

151. *American Rifleman*, Apr. 1964.

152. Drabold, *supra* note 146.

153. *About AR15 Hunter*, AR15 HUNTER (July 22, 2014, 8:26 P.M.), <http://ar15hunter.com/about-us/> [https://perma.cc/PMJ9-3GLZ].

154. Larosiére, *supra* note 129, at 12; Jim Wilson, *AR-15 Rifles for Home Defense? Yes!* NRA FAMILY (June 13, 2019), <https://www.nrafamily.org/articles/2019/6/13/ar-15-rifles-for-home-defense-yes/> [https://perma.cc/Z499-DRU8].

For example, a resident used his semi-automatic AK-47 to repel five armed home invaders in a Houston incident in January 2019.¹⁵⁵

Gun control advocates have mounted an effective disinformation campaign against the AR-15 by inaccurately stigmatizing it as a tool of warfare and crime, while ignoring the true basis of its popularity.¹⁵⁶ The true basis is that it is an extremely well-designed rifle readily mastered by shooters of all shapes, sizes, and skill levels, and is easily adapted to all manner of legitimate shooting applications.¹⁵⁷ The gun control lobby has very effectively built public and political support for their position but at a steep cost.¹⁵⁸ In relying upon such false claims and misleading tactics, they have badly provoked many responsible American gun owners, aborting any reasoned discussion of the problem of gun violence in the process.

IX. A FINAL OBSTACLE: THE POTENTIAL FOR ABUSE

It is not merely the divisive tactics of the gun control movement that put gun owners on their guard about red flag laws. There are also real concerns about the potential for error and abuse in the implementation of such laws.¹⁵⁹ As Dave Workman of the Second Amendment Foundation has said, “It’s a great idea on paper The problem is execution.”¹⁶⁰ A dramatic example of just how red flag laws can go wrong in the “execution” is the case of Gary Willis. He was killed by Maryland police in Anne Arundel County after the police arrived at his home, shortly after 5:00 in the morning on November 5, 2018, to execute an *ex parte* “extreme risk protective order” (ERPO).¹⁶¹ This order was issued at the request of his sister following a dispute over the care of their mother.¹⁶² While it can be

155. Stefania Okolie, *5 Shot and 3 Killed After Homeowner Opens Fire on Suspects in East Houston*, ABC EYEWITNESS NEWS (Jan. 20, 2019), <https://abc13.com/5-shot-and-3-dead-after-home-invasion-in-east-houston/5097015/> [<https://perma.cc/FZ43-63AP>].

156. See KLECK, *supra* note 38, at 73; David B. Kopel, *Trust the People: The Case Against Gun Control*, 3 J. ON FIREARMS AND PUB. POL’Y, 77, 77–78 (1990); Larosiére, *supra* note 129, at 5.

157. See Jon Schuppe, *America’s Rifle: Why So Many People Love the AR-15*, NBC NEWS (Feb. 15, 2018, 7:08 A.M.), <https://www.nbcnews.com/news/us-news/america-s-rifle-why-so-many-people-love-ar-15-n831171> [<https://perma.cc/2CMG-2BBA>].

158. See David B. Kopel, *The Costs and Consequences of Gun Control*, POL’Y ANALYSIS NO. 784 (Dec. 1, 2015), <https://www.cato.org/publications/policy-analysis/costs-consequences-gun-control> [<https://perma.cc/2WS8-QQPF>].

159. See generally Jacob Sullum, *States Are Depriving Innocent People of Their Second Amendment Rights*, REASON, Nov. 1991, at 47–51 (providing a concise overview of these concerns).

160. *Id.* at 51.

161. *Id.* at 47.

162. *Id.*

fairly said that Mr. Willis contributed to this tragic outcome by his ill-judged obstinate behavior in response to the police attempt to enforce the order, there would also seem to be some doubt as to whether an ERPO was appropriate in the first place. According to family, Mr. Willis “wasn’t dangerous, just strongly opinionated.”¹⁶³ His niece said that Mr. Willis “like[d] to speak his mind” but that he “wouldn’t hurt anybody.”¹⁶⁴ She added that the incident had left her “just dumbfounded now” and that the police “didn’t need to do what they did.”¹⁶⁵ However, for the Anne Arundel County Police Chief Timothy Altomare, the ambiguity of the situation served more to justify than to cast doubt on the validity of the EPRO. Altomare stated that “[i]f you look at this morning’s outcome, it’s tough for us to say ‘Well, what did we prevent?’ ... [b]ecause we don’t know what we prevented or could’ve prevented. What would’ve happened if we didn’t go there at 5 a.m.?”¹⁶⁶ In response, *Reason*’s Jacob Sullum tartly observed that “[w]ell, for one thing, Gary Willis probably would still be alive.”¹⁶⁷

Also impeding real dialogue is a concern over other types of potential government abuse of which gun owners are aware. One such is eminent domain abuse. This was dramatically brought to the public’s consciousness by the Supreme Court’s notorious holding in *Kelo v. City of New London*,¹⁶⁸ dramatized in the film *Little Pink House*.¹⁶⁹ Another is civil asset forfeiture abuse, recently addressed by the U.S. Supreme Court in *Timbs v. Indiana*.¹⁷⁰ Here, the Court held for the first time that the Eighth Amendment’s Excessive Fines clause is incorporated against the States via the Fourteenth Amendment.¹⁷¹ In this case, Tyson Timbs was convicted of selling about \$260 worth of heroine.¹⁷² In addition to the sentence of one year of home detention and five years’ probation imposed by the trial court, the State also seized his \$40,000 SUV.¹⁷³ Philadelphia¹⁷⁴ and Chicago¹⁷⁵

163. *Id.*

164. *Id.*

165. *Id.*

166. Phil Davis, *Anne Arundel Police Chief: Shooting Was Evidence That Month-Old “Red Flag” Law Is Needed*, TCA REG’L NEWS, Nov. 6, 2018.

167. Sullum, *supra* note 159, at 47.

168. *Kelo v. City of New London*, 545 U.S. 469 (2005) (holding that an interpretation of “public use” may be broadened to “public purpose” within the meaning of the Takings Clause).

169. LITTLE PINK HOUSE (Korchula Productions 2017).

170. *Timbs v. Indiana*, 586 S. Ct. 682, 684–87 (2019).

171. *Id.* at 685–87.

172. Kellie Hwang, *An Indiana Man Was Caught With \$260 of Heroin. The State Took His \$42,000 Land Rover*, INDYSTAR (Nov. 30, 2018, 11:44 A.M.), <https://www.indystar.com/story/news/2018/11/30/civil-forfeiture-timbs-v-indiana-scotus-supreme-court/2148377002/> [<https://perma.cc/Q56S-9YFS>].

173. *Timbs*, 586 S. Ct. at 686.

174. See DICK M. CARPENTER II, ET AL., INST. FOR JUST., POLICING FOR PROFIT: THE ABUSE OF CIVIL ASSET FORFEITURE 19 (2d ed. Nov. 2015).

have implemented even more kafkaesque forfeiture regimes. Given some municipalities' callous disregard of their citizens' property rights, it is hardly inconceivable that states and municipalities, hostile to gun ownership, might abuse the power vested in them under red flag laws to harass law abiding gun owners and relieve them of their firearms, if only temporarily.¹⁷⁶

CONCLUSION

In warfare, “[t]reachery or [p]erfidy”—acts such as “feign[ing] surrender” or falsely “broadcast[ing] to the enemy that an armistice has been agreed upon”—are “forbidden because [they] destroy[] the basis for a restoration of the peace short of the complete annihilation of one belligerent by another.”¹⁷⁷ The pro and anti-gun movements are not literally at war, of course. Nonetheless, the gun control movement's rhetoric—mischaracterizing the nature and capabilities of the AR-15; constantly shifting targets as to which guns are “bad” and merit proscription and which may be tolerated in private hands; and repeated, brazen insistence, against all evidence to the contrary, that the AR-15 neither has legitimate use nor is commonly used for any purposes but combat and mass murder—has gravely impeded constructive discourse on the question. The rhetorical excesses of gun control advocates have “destroy[ed] the basis for”¹⁷⁸ real, effective discussions about how to curb gun violence by convincing gun owners that the gun control lobby's true objectives are the total annihilation of America's firearms tradition and the *de facto*, if not *de jure*, repeal of the Second Amendment, and that any proposals that may be enacted will be just one more click on the implacable ratchet toward their goal of obliterating gun rights altogether.

Even worse is the impact that these false arguments have on members of the gun control movement itself. In focusing on certain weapons like the AR-15 as particularly “bad” compared to other firearms,

175. See Inst. for Justice, Chicago Impound: The Windy City Tows the Cars of Innocent People and Holds Them for Ransom, <https://ij.org/utility/case-print/?case-name=123791> [<https://perma.cc/KUP8-HB6C>]; John Pearley Huffman, *An Inside Look at Chicago's Seedy Car-Impound Netherworld*, CAR AND DRIVER (Aug. 25, 2019), https://www.caranddriver.com/features/a28776512/impounded-cars-chicago/?mkt_tok=eyJpIjoiTm1ZMU1EazRNV1ZpT1RjMiIsInQiOiJCUHNzVkdGT2JBaGFCQlFlamNDc3JpMTNPWFBBteForMUVVdzJoMVBSZjZtWnZ6c1RadUxySHA1RFdHaG4xR1wvSWtmaVwvMUJmc0xsWHdlZFBCl1FiYXRiYTNwUFJmQzdndUjFNuKJMTXkwMDM3ekIzZU1peStnNm5YWW5lYTtVRc0liaSJ9 [<https://perma.cc/6JL6-FW7A>].

176. See generally CARPENTER II, ET AL., *supra* note 174, at 2–3 (providing an overview of the problem of civil asset forfeiture abuse).

177. DEP'T OF THE ARMY, THE LAW OF LAND WARFARE 22 (July 1956).

178. *Id.*

the gun control movement has inculcated in its supporters the unrealistic belief that if only these particularly “wicked” firearms were eliminated, the problem of gun violence would be greatly reduced. This, in turn, has the effect of relieving states, municipalities, and the Federal Government of the expensive, tedious, and time-consuming work that might really prevent some of these tragedies. As Kevin Williamson noted,

What’s missing is ordinary, unglamorous, labor-intensive law-enforcement and public-health work ... We complain about ‘straw buyers’ but rarely prosecute them; some federal prosecutors refuse as a matter of publicly stated policy to take a straw-buyer case unless it is part of a larger (sexier) organized-crime investigation. ... On and on it goes: Ordinary crime and ordinary criminals, ordinary bureaucratic failure, and the occasional act of armed histrionics to keep the headlines churning.¹⁷⁹

One of my favorite books as a youth was written by Soviet defector Vladimir Bogdanovich Rezu, writing pseudonymously as Victor Suvorov.¹⁸⁰ This book, *Inside the Soviet Army*, contains a very important leadership lesson that any soldier must learn: “[a]fter some time you will come to understand the most important rules of all, one which you have never been taught – respect your soldiers.”¹⁸¹ However, the real point is what he adds a few lines later: that respecting your soldiers “means more than just showing them respect.”¹⁸² A commander respects his soldiers by “[s]how[ing] that [he] care[s] about them by meeting their needs whenever possible [and by] [c]onsider[ing] them as men—with problems, hopes, and feelings—just like [himself].”¹⁸³ What relevance do these observations have for the debate over firearms in America? Only this: in the aftermath of *District of Columbia v. Heller*,¹⁸⁴ gun control activists have been forced to

179. Kevin D. Williamson, *How to Spot a Serious Gun-Crime Proposal*, NAT’L REV. (Sept. 3, 2019, 2:43 P.M.), <https://www.nationalreview.com/2019/09/how-to-spot-a-serious-gun-crime-proposal/> [<https://perma.cc/2AMG-4VNX>].

180. Luke Harding, “*Will They Forgive Me? No*”: *Ex-Soviet Spy Viktor Suvorov Speaks Out*, THE GUARDIAN (Dec. 29, 2018), <https://www.theguardian.com/world/2018/dec/29/ex-soviet-spy-viktor-suvorov> [<https://perma.cc/6RYA-ABB4>].

181. VIKTOR SUVOROV, *INSIDE THE SOVIET ARMY* 257 (Macmillan Publ’g Co., Inc., 1982).

182. *Id.* at 257–58.

183. DANDRIDGE M. MALONE, *SMALL UNIT LEADERSHIP: A COMMONSENSE APPROACH* 33 (Presidio Press, 1983).

184. *District of Columbia v. Heller*, 554 U.S. 570, 602, 635 (2008) (holding that the Second Amendment protects an individual’s right to keep and bear arms).

pay grudging homage to the individual right to keep and bear arms.¹⁸⁵ However, American gun owners remember the contrary assertions of these same activists: that the Second Amendment did not codify such an *individual* right, but only a collective guarantee intended to “protect members of a state militia from being disarmed by the federal government,”¹⁸⁶ and that “the majority of Americans mistakenly believe that the Second Amendment of the Constitution guarantees the individual right to keep and bear arms.”¹⁸⁷ Just as respecting Suvorov’s soldiers meant more than merely treating them with respect, “respecting” the right to keep and bear arms means more than making an empty obeisance to it. Really respecting the right means taking the time to understand the true nature of firearms, developing proposals that are effective in reducing gun violence, and doing so in a way that really respects the rights of peaceable law-abiding gun owners. These have been notably absent on the pro-control side of the debate.¹⁸⁸

Some gun control activists will never be satisfied until every last privately-owned firearm in the United States has been confiscated. By the same token, some gun rights advocates will never accept any firearms regulations whatsoever. Few people, however, fall into either of these extreme camps. Many gun owners are willing to consider measures that might actually contribute to a reduction in gun violence, as opposed to misguided and pointless proposals such as banning so-called “assault” weapons and “high-capacity” magazines. Unfortunately, given the acrimony to which the debate over guns has descended, and given the extent to which it has become encumbered by misinformation and error, substantial assurances are needed to bring American gun owners to the table; bland assertions of respect for the Second Amendment will not suffice.

Serious progress on the problem of gun violence, including mass shootings, depends upon acceptance by all parties of certain fundamental principles: (1) the right to keep and bear arms is an individual right, as set forth in *Heller* and *McDonald v. City of Chicago*;¹⁸⁹ (2) the Second Amendment protects the rights of peaceable citizens to acquire, possess, and use the firearms of their choice, including semi-automatic firearms such as the AR-15 and the magazines designed for them by their manufacturers; and (3) that real and effective due process protections must be respected

185. See The Cato Institute, *The Right to Keep and Bear Arms: 10 Years After Heller*, CATO POL’Y REP., Sept./Oct. 2018, at 16.

186. PETE SHIELDS, GUNS DON’T DIE – PEOPLE DO 55 (Arbor House Publ’g Co., 1981).

187. *Assault Weapons and Accessories in America*, *supra* note 43 (emphasis added).

188. See Kopel, *supra* note 158 (“Responsible firearms policies . . . do not attempt to infringe the constitutional rights of good persons.”).

189. *McDonald v. City of Chicago*, 561 U.S. 742, 749–50, 791 (2010).

before these rights may be abridged. Affirmation of these basic points by the United States Supreme Court would clear away much of the detritus clogging the debate about guns and violence and might facilitate the implementation of real, practical solutions in a way that has heretofore evaded us.

EXHIBIT 39

ASSAULT WEAPON BAN

Neither 'Capacity' Nor 'Power' Distinguishes 'Assault Weapons' From Other Firearms

The New York Times continues to push the myth that there is something uniquely deadly about the guns Dianne Feinstein wants to ban.

JACOB SULLUM | 10.31.2018 1:35 PM



Ruger Mini-14 Ranch Rifle



In an editorial published the day after the shooting that killed 11 people at a Pittsburgh synagogue on Saturday, *The New York Times* erroneously claimed that so-called assault weapons like the Colt AR-15 rifle used in that attack are distinguished by their

"high capacity." In a news story posted yesterday, *Times* reporter Richard A. Oppel Jr. suggests that AR-15-style rifles are especially "powerful," which also is not true.

Unlike, say, Barack Obama or Hillary Clinton, Oppel acknowledges that an AR-15, like any other semi-automatic, "fires one bullet at a time." Still, he says, "it is a powerful weapon: light, easy to hold and to fire, with limited recoil, its bullets shooting out of the muzzle more than twice as fast as most handgun rounds." The only part of that description that is related to "power" is the part about muzzle velocity, and here Oppel pulls the time-honored trick of comparing the rifles Dianne Feinstein hates with handguns instead of other rifles. Bullets fired from rifles generally move faster than bullets fired from pistols, mainly because a longer barrel gives them more room to accelerate. But that tells us nothing about the difference between the rifles Feinstein wants to ban—which are distinguished by features such as folding stocks, pistol grips, and barrel shrouds—and the ones she is willing to leave on the market.

Ruger Mini-14 Tactical Rifle

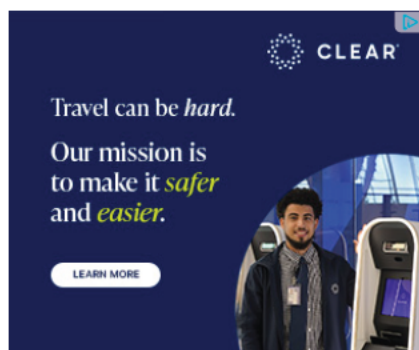


Ruger Mini-14 Ranch Rifle



These two weapons fire the same ammunition at the same rate with the same muzzle velocity and have the same capacity. But the first is listed by name as a banned gun in Sen. Feinstein's latest bill, while the second is specifically exempted.

Joanna Andreasson / Reason



If the comparison is limited to long guns, the .223-caliber round typically fired by AR-15-style rifles does have a relatively high muzzle velocity. But other cartridges, fired by guns that are not considered "assault weapons," equal or surpass it. Furthermore, muzzle velocity is not the only factor in a bullet's lethality; size also matters, and so-called assault weapons fire smaller rounds than many hunting rifles.

Oppel adds that "the standard AR-15 magazine holds 30 bullets and can be swapped out quickly, allowing a shooter to fire more than a hundred rounds in minutes." The ability to accept "high-capacity" magazines does not distinguish "assault weapons" from other guns, and Oppel's point about how quickly magazines can be switched undermines the argument that a 10-round limit would make mass shootings less deadly. In any case, any semi-automatic gun can fire "more than a hundred rounds in minutes," which would require, at most, pulling the trigger about once per second.

The *Times* has been helping to perpetuate the myth that there is something uniquely deadly about "assault weapons" for decades. But it also has intermittently published articles pointing out that the distinctions drawn by politicians like Feinstein make little sense, or at least acknowledging that perspective. Critical readers, even if they had no other source of information about "assault weapons," should be able to figure out that there is something fishy about the case for banning these guns. It's too bad there are not more of those on the paper's editorial board or reporting staff.

EXHIBIT 40

Review Article

Gunshot Wounds: 1. Bullets, Ballistics, and Mechanisms of Injury

Jeremy J. Hollerman,¹ Martin L. Fackler,² Douglas M. Coldwell,³ and Yoram Ben-Menachem⁴

The nature and severity of a bullet wound depend on the characteristics of the bullet and of the tissues through which it travels. In addition to the mass and velocity of the bullet, its orientation and whether it fragments or deforms affect the nature of the wound. Two major mechanisms of wounding are described: crushing and stretching of tissue. Understanding the mechanisms by which bullets disrupt tissue can help physicians to evaluate and treat wounds.

The characteristics and severity of a gunshot wound are determined by the design of the weapon and projectile, the intermediate targets the projectile encounters between the gun muzzle and the body, and the sequence of tissues encountered along the projectile path. Although the skill of the person firing the weapon affects the trajectory, chance also plays a role. If the missile path includes a large bone, or if the projectile strikes a button, belt buckle, or other hard object, the severity of the wound often increases [1, 2]. To some extent, whether the bullet hits a particular wound-modifying structure (surface or anatomic) is a chance event. For any projectile, if the path includes a critical anatomic structure, the result may be fatal, just as if the structure had been stabbed by a knife. In general, projectile wounds are most severe when the missile yaws early in its path through tissue, fragments, is large, and is traveling at high speed.

Civilian bullets are often more damaging to tissue than are military bullets fired from rounds otherwise configured identi-

cally [1, 3]. (A round is one complete unit of ammunition. This includes the bullet, the cartridge case, the powder, and the primer.) Unlike military bullets, civilian bullets are not required to have a full metal jacket (a metal jacket completely covering the bullet tip [3]), and are therefore much more likely to deform or fragment in tissue. Because of this, wounds produced by civilian hunting rifles, shotguns, and large-caliber handguns are often more severe than military combat wounds [3]. An enemy soldier wounded in war, who is sufficiently disabled to no longer fight but is not killed, uses more enemy resources than one who is killed. In addition to the loss of the soldier on the battlefield, personnel and material are required to care for and feed the wounded soldier.

Mechanisms of Wounding

Both missile and tissue characteristics determine the nature of the wound. Missile characteristics are partly inherent (mass, shape, construction) and are partly conferred by the weapon (longitudinal and rotational velocity). Tissue characteristics (elasticity, density, anatomic relationships) also strongly affect the nature of the wound. The severity of a bullet wound is influenced by the bullet's orientation during its flight through tissue and by whether the bullet fragments [1] or deforms (into, for example, the typical mushroom shape of the expanding hollow-point or soft-point bullet).

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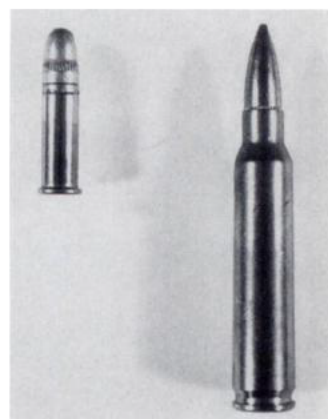
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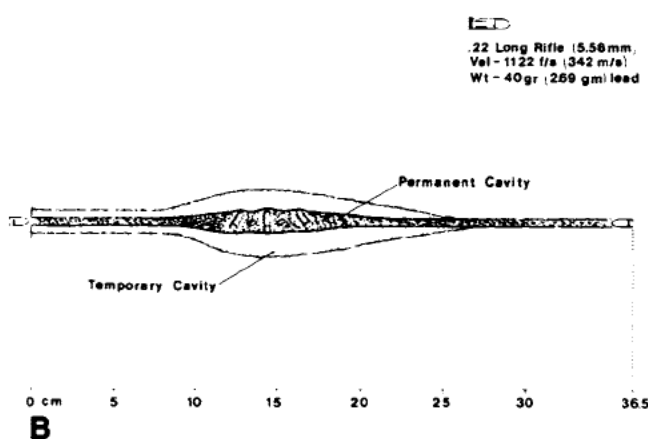
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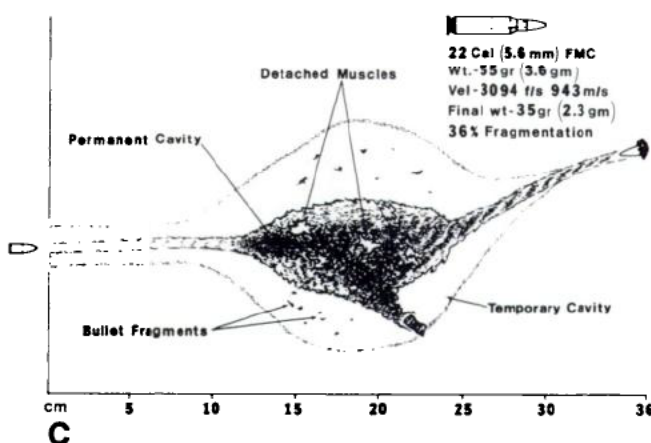
A

Fig. 1.—A, Photograph shows .22 long-rifle round (left) and M16 round (right).
B and C, Wound profiles of same .22 long-rifle (B) and .224 caliber M-193 round of M16A1 rifle (C). (Full metal case [FMC] is a synonym for full metal jacket [FMJ], type of bullet used in military.)

This figure shows that caliber (bullet diameter in hundredths of an inch) is only one indicator of wounding potential, and not a very good one. Because of much higher velocity (3094 ft/sec [943 m/sec], as opposed to 1122 ft/sec [342 m/sec] for the .22 long-rifle bullet), because it fragments in tissue, and because of the greater bullet mass, the M16 bullet potentially can cause a much more severe wound if part struck is sufficiently thick. Note that both permanent cavity and temporary cavity are much larger. As is usual, temporary and permanent cavities of .22 long-rifle bullet are largest when bullet is at 90° of yaw.



B



C

Two major mechanisms of wounding occur: the crushing of the tissue struck by the projectile (forming the permanent cavity), and the radial stretching of the projectile path walls (forming a temporary cavity) (Fig. 1).

In addition, a sonic pressure wave precedes the projectile through tissue. The sonic pressure wave plays no part in wounding. In air, the speed of sound is approximately 300 m/sec; in soft tissue, it is approximately 1500 m/sec. When a bullet enters soft tissue, the sonic pressure wave forms a hemispherical arc ahead of the advancing bullet. The short-lived sonic pressure pulse created may reach pressures of up to 100 atm (1.01×10^7 Pa). The duration of this pulse is approximately 2 μ sec [4]. Research reported in 1947 [5] determined that this sonic shock wave has no damaging effect on tissue, a finding since confirmed by clinical experience with sonic pressure wave lithotripsy, in which tissue receives sonic pressure waves two to three times greater than that produced by a supersonic rifle bullet [6]. The sonic pressure wave must not be confused with the temporary cavity, which is discussed later.

Crushing of Tissue

A missile crushes the tissue it strikes, thereby creating a permanent wound channel (permanent cavity). Yaw is the

angle between the long axis of the bullet and its path of flight. If the bullet is traveling with its pointed end forward and its long axis parallel to the longitudinal axis of flight (0° of yaw), it crushes a tube of tissue no greater than its approximate diameter. When the bullet yaws to 90°, the entire long axis of the bullet strikes tissue, and the amount crushed may be three times greater than at 0° of yaw.

When striking soft tissue with sufficient velocity, soft-point and hollow-point bullets deform into a mushroom shape. This increases surface area and wound severity. For most big-game hunting, such bullets are mandated by law. This is to increase the probability of killing quickly, rather than creating a disabling but nonlethal wound, allowing escape and prolonged suffering. If the mushroomed diameter is 2.5 times greater than the initial diameter of the bullet, the area of tissue crushed by the bullet is 6.25 times greater than the amount that would have been crushed by the undeformed bullet.

Bullet fragmentation also increases the volume of tissue crushed [1, 7]. After bullet fragmentation, surface area is increased, and much more tissue is crushed. For large handgun (e.g., .44 magnum) and rifle bullets, the striking of bone is one of the causes of early bullet fragmentation.

Comminuted fracture may be created by rifle and large handgun bullets striking bone (Fig. 2). Bone fragments can become secondary missiles, crushing tissue. Many handgun



Fig. 2.—Radiograph shows a severely disruptive bullet wound of leg. Gross comminution of fractures, missile fragmentation, and severe soft-tissue disruption suggest either a large-caliber handgun, a rifle, or a shotgun with large-diameter shot such as .00 buckshot. This wound was due to a large handgun (probably a .44 magnum). A center-fire rifle or large handgun is much more likely to produce severely comminuted fracture than is a smaller handgun. Soft-tissue and vascular damage associated with these fractures delays healing and increases complications.

bullets are unable to fragment bone significantly. When a large bone is struck, it is likely that a bullet will expend its wounding potential in the patient and will not exit.

Bullet fragments and secondary missiles (bone fragments, teeth, dental fillings, coins, etc.) are likely to increase the severity of the wound. Multiple perforations weaken tissue and create focal points for stress (stress risers), which are particularly vulnerable to the effect of temporary cavitation stretch [1, 4].

Unjacketed lead bullets cannot be driven faster than about 2000 ft/sec (610 m/sec) without some of the lead stripping off in the barrel of the gun. This is avoided if a jacket made of a harder metal (such as copper or a copper alloy), is used to surround the lead. The jacket of a military bullet completely covers the bullet tip (a full metal jacket). Civilian hollow-point and soft-point bullets usually have a jacket that surrounds part of the bullet (a semi-jacketed bullet), leaving the front portion exposed so that it can expand.

The soft-point and hollow-point bullets of center-fire rifle rounds usually deform into a mushroom shape in tissue, increasing the volume of tissue crushed. In contrast, even the magnum versions of some handgun bullets designed for expansion fail to mushroom [8]. This is most likely with short-barrel handguns. The shorter the barrel length, the shorter the time available for bullet acceleration by the expanding gases created by burning gunpowder. Therefore, when identical rounds are fired, the gun with the shorter barrel produces a lower-velocity bullet. Its velocity may be too low to induce mushrooming after impact.

Mushroom-type expansion is intended with civilian hollow-point and soft-point bullets. They also can fragment. Military

full-metal-jacket bullets either stay intact or fragment; they do not mushroom. Although the M-193 military bullet of the M16 rifle fragments in soft-tissue with a characteristic pattern depending on range [9, 10], other full-metal-jacket military bullets, such as those fired from the AK-47, the AK-74, and the NATO 7.62-mm rifle (American version), typically do not fragment unless they strike bone.

Temporary Cavitation (Tissue Stretch)

During flight, a bullet is stabilized against yaw by the spin imparted to it by the spiral grooves (rifling) in the gun barrel [11]. The longer (and heavier) the bullet in relation to its diameter, the more rapidly it must be rotated to avoid significant yaw in flight. Therefore, a gun barrel intended to fire a heavier bullet has rifling that makes a full turn in fewer inches of barrel length than the rifling in a barrel intended for a shorter, lighter bullet of the same caliber.

Fired from an appropriate and well-designed weapon, a bullet flies in air with its nose pointed forward; it yaws only 1 to 3° [6]. Yaw occurs around the bullet's center of mass [6]. In pointed rifle bullets, the center of mass is behind the midpoint of the bullet's long axis. Although the bullet's most naturally stable in-flight orientation would be with its heaviest part forward, for aerodynamically efficient flight, it must fly point forward.

Although the bullet's spin is adequate to stabilize it against yaw in its flight through air, it is not adequate to stabilize it in its path through tissue, because of the higher density of the medium [12]. If it does not deform, a pointed bullet eventually yaws to a base-forward position (180° of yaw). Expanding bullets lose the physical stimulus to yaw, because after "mushrooming" their heaviest part is forward.

As a bullet passes through 90° of yaw, it is crushing its maximal amount of tissue (unless it fragments, which will crush more). It is slowed down rapidly, as its wounding potential is used up moving tissue radially away from its path. This force creates the temporary cavity. This aspect of the wounding process is analogous to the splash of a diver entering the water.

If a diver enters the water very straight and point forward (similar to the point-forward configuration of a bullet at zero degrees of yaw), the splash may be minimal. If the diver does a belly-flop (similar to a bullet at 90° of yaw), a large splash is induced. In tissue, this splash, the temporary cavity, produces localized blunt trauma (Fig. 3) [1, 4].

The maximal size of the temporary cavity occurs several milliseconds after the bullet has passed through the tissue [11]. Because forces follow paths of least resistance, temporary cavitation is likely to be asymmetric and spread out through tissue planes [4].

The temporary cavity caused by common handgun bullets is too small to be a significant wounding factor in all but the most sensitive tissues (brain and liver) [4]. Center-fire rifle bullets and large handgun bullets (e.g., .44 magnum) often induce a large temporary cavity (10–25 cm [4–10 in.] diameter) in tissue. This can be a significant wounding factor, depending on the characteristics of the tissue in which it forms [4, 13].

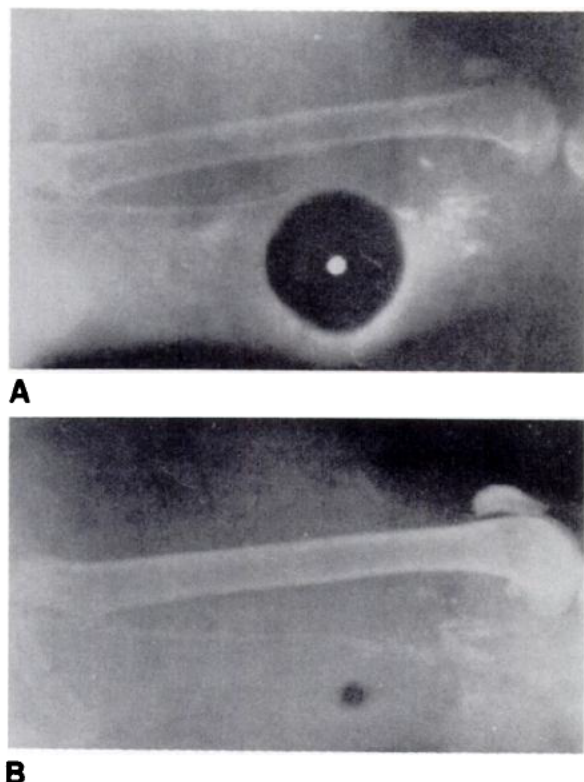


Fig. 3.—A and B, High-speed radiographs of thigh of a cat during (A) and after (B) passage of a 4/32-in. (3.2 mm) steel sphere with impact velocity of 3200 ft/sec (975 m/sec). Sciatic nerve of cat's thigh made radiopaque with iodobenzene. Images obtained with beam parallel to path of missile.

Microsecond radiograph during passage (A) shows anterior displacement of sciatic nerve by temporary cavity. Tissues surrounding path of projectile are undergoing blunt trauma and tissue stretch because of temporary cavity formation.

Radiograph made immediately after shot (B) shows permanent cavity (wound channel) is considerably smaller than temporary cavity. Sciatic nerve is in its usual anatomic position. Nerve and vessel injury from stretch may have occurred. (Courtesy of Leonard D. Heaton, James B. Costes, Jr., and James C. Beyer; reprinted with permission from *Wound Ballistics*, Office of the Surgeon General, Department of the Army, 1962, p. 209.)

Near-water-density, less elastic tissue (e.g., brain, liver, or spleen), fluid-filled organs (including the heart, bladder, or gastrointestinal tract), and dense tissue (e.g., bone) may be damaged severely when a large temporary cavity contacts them [11]. More elastic tissue (e.g., skeletal muscle) and lower-density elastic tissue (e.g., lung) are less affected by the formation of a temporary cavity [14, 15]. Because of these tissue differences, the transmitted forces of temporary cavitation caused by a bullet traveling 800–950 m/sec can cause a more severe pulmonary contusion when the bullet traverses the chest wall musculature than the pulmonary contusion that would have occurred had the same bullet passed directly through the lung [3, 15, 16].

Although formation of a large temporary cavity often has devastating effects in the brain or liver, its effect in wounds of the extremities has frequently been exaggerated in articles about wound ballistics [4, 6, 17]. Fracture of large bones not hit by the bullet and tearing of major vessels or nerves by the temporary cavity are often mentioned in the literature (e.g.,

DeMuth [3]), but are rare in clinical experience. This includes a systematic review of 1400 rifle wounds sustained in the Vietnamese War and analyzed in the Wound Data and Munitions Effectiveness Team (WDMET) study (Bellamy RF, personal communication). Most of the permanent damage in wounds of the extremities is the result of structures being hit by the intact bullet, bullet fragments, or secondary missiles. As in all blunt trauma, shear forces develop and tear structures at points where one side is fixed and the other side is free to move. The temporary cavity is no exception. In the unlikely event that the blunt trauma of the temporary cavity tears a vessel wall, this is particularly likely to occur at the vessel origin.

Ballistic Properties and the Wound Produced

Recent controlled animal experiments with military rifle bullets [18] have clearly disproved the assertion that all tissue exposed to temporary cavitation is destroyed. These studies also show that not only does the 14-cm-diameter temporary cavity produced by the AK-74 assault rifle not destroy a great amount of muscle, but the sizable stellate exit wound it causes in the uncomplicated thigh wound ensures excellent wound drainage, which assists healing [14, 18, 19]. This is consistent with the pathophysiology of wound healing and the history of the treatment of wounds received in war [18, 19]. A history that the wound was caused by a "high-velocity bullet" does not mandate radical excision of the wound path [4, 6, 13, 14, 19–21].

The characteristics of the wounded tissue, the thickness of the body part, the point in the path of the bullet at which yaw or fragmentation occurs, and other factors strongly influence the wound produced. Bullets of equal wounding potential may produce wounds of quite different severity, depending on which tissues they traverse. The heavier, slower bullet crushes more tissue but induces less temporary cavitation. Most of the wounding potential of the lighter, faster bullet is likely to be used up forming a larger temporary cavity, but this bullet leaves a smaller permanent cavity. The heavier, slower bullet causes a more severe wound in elastic tissue than the lighter, faster bullet, which uses up much of its potential producing tissue stretch (temporary cavitation). This tissue stretch may be absorbed with little or no ill effect by elastic tissue such as lung or muscle. In nonelastic tissue, such as liver or brain, the temporary cavity produced by the lighter, faster bullet can produce a more severe wound.

Experiments with ballistic gelatin (which duplicates the projectile deformation and penetration depth of living animal muscle [13]) have shown that most full-metal-jacketed rifle bullets yaw significantly only at tissue depths greater than the diameter of human extremities [10]. In the first 12 cm (the average thickness of an adult human thigh) of a soft-tissue wound path, there is often little or no difference between the wounding effects of low- and high-velocity bullets when the high-velocity bullet is of the military full-metal-jacket type [4, 10]. This is particularly true of the relatively heavier military rifle bullets, such as those fired by the AK-47 and NATO 7.62-mm (American version) rifles [4]. A wound of an extremity caused by an AK-47 bullet that does not hit bone is often

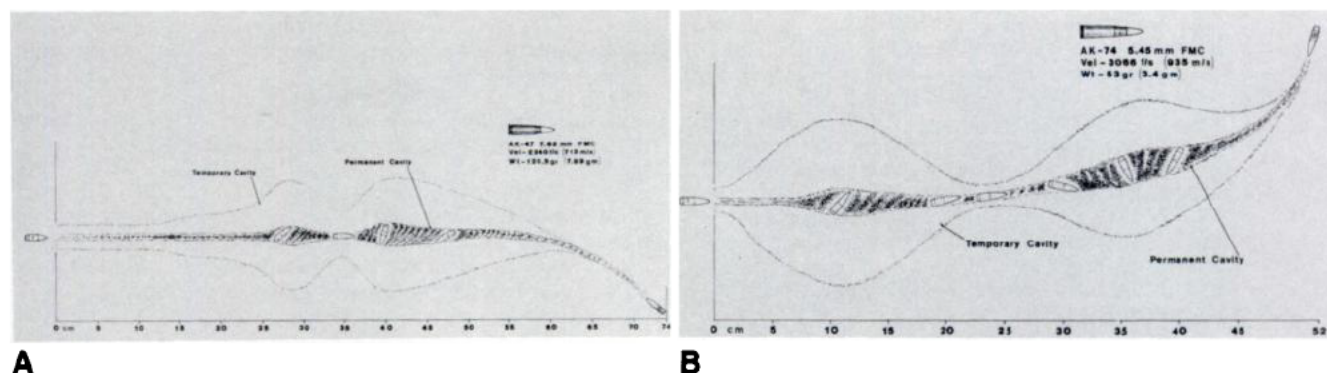


Fig. 4.—A and B, These wound profiles illustrate use of ballistic principles for “wound design.” Wound profiles of AK-47 (A) and AK-74 (B) bullets in ballistic gelatin are presented. AK-47 has been standard military rifle of Soviet bloc but is being replaced with AK-74. AK-47 fires a 7.62-mm full-metal-jacket (FMC) bullet 7.62 mm in diameter at a muzzle velocity of 713 m/sec (2340 ft/sec). AK-74 fires a 5.45-mm, 3.4-g FMC bullet at 935 m/sec (3066 ft/sec). AK-74 bullet is designed to yaw earlier in its wound path than AK-47 bullet does (see text). Extremity wounds from AK-74 can be expected to be much more severe than those from AK-47. This is especially true for wound paths in extremities that are entirely through soft tissue and do not include a large bone.

similar to a handgun bullet wound. A soft- or hollow-point bullet fired from a civilian rifle deforms soon after entering tissue and produces a much more severe extremity wound. Compare the first 12 cm of the wound profile of the .22 long-rifle round in Figure 1 with the wound profile of the AK-47 round in Figure 4. If a high-velocity, heavy bullet does not deform, fragment, or hit a bone, it may exit an extremity with much of its wounding potential unspent. These same bullets are often lethal in chest or abdominal wounds because the trunk is thicker than an extremity and allows the bullet a sufficiently long path through tissue to yaw. Note that maximal temporary cavitation induced by the AK-47 bullet (Fig. 4A) during the first cycle of bullet yaw is at a tissue depth of 28 cm, much greater than the diameter of a human extremity. The second cycle of bullet yaw occurs at a depth too great to be of significance in most wound paths in humans.

The AK-74 bullet (Fig. 4B) is lighter than the AK-47 bullet and is internally constructed to cause early yaw. It causes its maximal temporary cavity at a tissue depth of 11 cm. Extremity wounds from the AK-74 can be expected to be much more severe than those from the AK-47 [9, 22]. The lighter, smaller round allows a soldier to carry many more rounds of ammunition. This was the primary motivation for development of the M16 and the AK-74 [4].

Figure 1 shows that caliber (bullet diameter in hundredths of an inch) is only one indicator of wounding potential, and it is not a very good one. Although the .22 long-rifle bullet and the M-16 bullet are similar in diameter (caliber), the M16 bullet is heavier (3.6 vs 2.7 g for the .22 long-rifle bullet), mainly because the M16 bullet is longer. Each bullet is seen protruding from the end of its cartridge case. The bullet is the portion of the round that leaves the end of the gun barrel after firing. Because of its much higher velocity (3094 ft/sec [943 m/sec]), as opposed to 1122 ft/sec [342 m/sec] for the .22 long-rifle bullet, because it fragments in tissue, and because of its greater bullet mass, the M16 bullet causes a much more severe wound. Note that both the permanent cavity and the temporary cavity are much larger. As is usual, the temporary and permanent cavities of the .22 long-rifle bullet are largest

when the bullet is at 90° of yaw. Note also that the large temporary and permanent cavities formed by the M16 bullet occur mainly from 11 to 30 cm deep in tissue. The bullet has its highest velocity when it enters the tissue, but forms a small wound channel at that point. Only when it fragments or yaws to 90° is its severe wounding effect realized. At that point it is traveling slower. Bullet velocity, then, is only one factor in wounding [7, 20, 23].

Bullets are not sterilized by the heat of firing. They can carry bacteria from the body surface or body organs, including a penetrated colon, deep into the wound [12, 24].

Conclusions

Understanding the mechanisms by which penetrating projectiles disrupt tissue can assist the physician in evaluating and treating the wound in a rational manner. Both missile and tissue characteristics determine the nature of the wound.

Two major mechanisms of wounding exist: crushing and stretching of tissue. The elasticity and density of a tissue and the thickness of the body part wounded strongly affect the wound produced. Missile mass, construction, tendency to fragment or yaw, and velocity are key factors in determining the wounding potential of a missile. Velocity often dominates discussions of wound ballistics; however, a bullet can inflict more lethal damage to tissue by fragmentation and yaw than by high velocity.

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